Isolated Carbonate Bodies Composed of Stacked Debris-Flow Deposits on a Fine-Grained Carbonate Lower Slope of Devonian Age, Antelope Peak, Elko County, Nevada

U.S. GEOLOGICAL SURVEY BULLETIN 1988–E

AVAILABILITY OF BOOKS AND MAPS OF THE U.S. GEOLOGICAL SURVEY

Instructions on ordering publications of the U.S. Geological Survey, along with prices of the last offerings, are given in the current-year issues of the monthly catalog "New Publications of the U.S. Geological Survey." Prices of available U.S. Geological Survey publications released prior to the current year are listed in the most recent annual "Price and Availability List." Publications that may be listed in various U.S. Geological Survey catalogs (**see back inside cover**) but not listed in the most recent annual "Price and Availability List" may no longer be available.

Reports released through the NTIS may be obtained by writing to the National Technical Information Service, U.S. Department of Commerce, Springfield, VA 22161; please include NTIS report number with inquiry.

Order U.S. Geological Survey publications **by mail** or **over the counter** from the offices listed below.

BY MAIL

Books

Professional Papers, Bulletins, Water-Supply Papers, Techniques of Water-Resources Investigations, Circulars, publications of general interest (such as leaflets, pamphlets, booklets), single copies of Earthquakes & Volcanoes, Preliminary Determination of Epicenters, and some miscellaneous reports, including some of the foregoing series that have gone out of print at the Superintendent of Documents, are obtainable by mail from

U.S. Geological Survey, Map Distribution
Box 25286, MS 306, Federal Center
Denver, CO 80225

Subscriptions to periodicals (Earthquakes & Volcanoes and Preliminary Determination of Epicenters) can be obtained ONLY from the

Superintendent of Documents
Government Printing Office
Washington, DC 20402

(Check or money order must be payable to Superintendent of Documents.)

Maps

For maps, address mail orders to

U. S. Geological Survey, Map Distribution
Box 25286, Bldg. 810, Federal Center
Denver, CO 80225

Residents of Alaska may order maps from

U.S. Geological Survey, Earth Science Information Center
101 Twelfth Ave., Box 12
Fairbanks, AK 99701

OVER THE COUNTER

Books and Maps

Books and maps of the U.S. Geological Survey are available over the counter at the following U.S. Geological Survey offices, all of which are authorized agents of the Superintendent of Documents.

- **ANCHORAGE, Alaska**–Rm. 101, 4230 University Dr.
- **LAKEWOOD, Colorado**–Federal Center, Bldg. 810
- **MENLO PARK, California**–Bldg. 3, Rm. 3128, 345 Middlefield Rd.
- **RESTON, Virginia**–USGS National Center, Rm. 1C402, 12201 Sunrise Valley Dr.
- **SALT LAKE CITY, Utah**–Federal Bldg., Rm. 8105, 125 South State St.
- **SPOKANE, Washington**–U.S. Post Office Bldg., Rm. 135, West 904 Riverside Ave.
- **WASHINGTON, D.C.**–Main Interior Bldg., Rm. 2650, 18th and C Sts., NW.

Maps Only

Maps may be purchased over the counter at the following U.S. Geological Survey offices:

- **FAIRBANKS, Alaska**–New Federal Bldg, 101 Twelfth Ave.
- **ROLLA, Missouri**–1400 Independence Rd.
- **STENNIS SPACE CENTER, Mississippi**–Bldg. 3101

Isolated Carbonate Bodies Composed of Stacked Debris-Flow Deposits on a Fine-Grained Carbonate Lower Slope of Devonian Age, Antelope Peak, Elko County, Nevada

By Peter M. Sheehan, John M. Pandolfi, *and* Keith B. Ketner

EVOLUTION OF SEDIMENTARY BASINS—EASTERN GREAT BASIN
Harry E. Cook and Christopher J. Potter, Project Coordinators

---

U.S. GEOLOGICAL SURVEY BULLETIN 1988–E

A multidisciplinary approach to research studies of sedimentary rocks and their constituents and the evolution of sedimentary basins, both ancient and modern

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1993

U.S. DEPARTMENT OF THE INTERIOR

BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY

Robert M. Hirsch, Acting Director

For sale by
USGS Map Distribution
Box 25286, Building 810
Denver Federal Center
Denver, CO 80225

Library of Congress Cataloging-in-Publication Data

Sheehan, Peter M.
Isolated carbonate bodies composed of stacked debris-flow deposits on a fine-grained carbonate lower slope of Devonian age, Antelope Peak, Elko County, Nevada / by Peter M. Sheehan, John M. Pandolfi, and Keith B. Ketner.
p. cm. — (U.S. Geological Survey bulletin ; 1988–E)
(Evolution of sedimentary basins—Eastern Great Basin ; ch. E)
Includes bibliographical references.
Supt. of Docs. no.: I 19.3: 1988E
1. Rocks. Carbonate—Nevada—Elko County. 2. Geology, Stratigraphic—Devonian. 3. Geology—Nevada—Elko County. I. Pandolfi, John M. II. Ketner, Keith Brindley, 1921– . III. Title. IV. Series. V. Series: Evolution of sedimentary basins—Eastern Great Basin ; ch. E.
QE75.B9 no. 1988–E
[QE471.15.C3]
557.3 s—dc20 93–3544
[552′.58′0979316] CIP

CONTENTS

FIGURES

TABLE

Isolated Carbonate Bodies Composed of Stacked Debris-Flow Deposits on a Fine-Grained Carbonate Lower Slope of Devonian Age, Antelope Peak, Elko County, Nevada

By Peter M. Sheehan,[1] John M. Pandolfi,[2] *and* Keith B. Ketner[3]

ABSTRACT

The Roberts Mountains Formation at Antelope Peak in northeastern Nevada contains Lower Devonian isolated carbonate bodies in a predominantly thin-bedded carbonate-turbidi te sequence. The largest of five exposed bodies is 600 m wide and 47 m high. The turbidites that enclose the bodies were deposited on an outer carbonate apron near the margin of a basin. The carbonate bodies are composed of as many as 150 discrete, matrix-supported conglomerate beds, each of which was deposited by a separate debris-flow event. Clasts in the conglomerate beds are as much as 90 cm in diameter and were derived from the shallow carbonate shelf. Clasts include angular carbonate blocks, colonial corals, and large segments of fused pelmatozoan stems. The debris-flow deposits are interpreted to have been derived from a point source on the shelf margin. Because numerous conglomerate beds were deposited at single locations, the debris flows may have been channeled down long canyons incised on the carbonate slope, then deposited as fanlike bodies at the mouths of the canyons.

INTRODUCTION

Lower Devonian resistant, isolated carbonate bodies are present near the transition between outermost carbonate slope and basin in the Antelope Peak area of northeastern Nevada (fig. 1). We interpret the 10–47-m-thick carbonate bodies to have an allochthonous origin and to be composed of stacks of numerous carbonate mud-supported sediment gravity-flow deposits.

Resedimented material deposited near carbonate shelf margins is commonly derived from line sources (Schlager and Chermak, 1979). Line sources produce slope deposits in broad aprons arrayed parallel to the shelf margin (Cook and others, 1972, 1983; Cook and Mullins, 1983; Mullins, 1983; Mullins and others, 1984; Mullins and Cook, 1986). The aprons commonly are composed of grain flows, debris flows, turbidites and periplatform ooze. In contrast, noncarbonate slopes are characterized by point sources; fans of sediment radiate from canyons that are fed clastic material by rivers and longshore currents (Mutti and Ricci Lucchi, 1978; Normark, 1978). Point-source deposits similar to siliciclastic fans are uncommon in carbonate systems (Cook and Egbert, 1981; Cook, 1983; Ruiz-Ortiz, 1983; Wright and Wilson, 1984).

In a review and expansion of the carbonate apron model, Mullins and Cook (1986) recognized two types of aprons, the carbonate slope apron, developed along relatively gentle platform-margin slopes, and the base-of-slope carbonate apron, developed on relatively steep slopes. The isolated carbonate bodies discussed herein are on the outermost part of a base-of-slope carbonate apron. These bodies were built upward by repeated sediment gravity-flow deposits derived from localized point sources on the shelf margin. The clasts comprising the bodies bypassed the upper carbonate slope and most of the carbonate apron before being deposited at the basin margin.

Acknowledgments.—Research was supported by National Science Foundation grant EAR–7901013 to P.M. Sheehan. E.M. Schwartz and R.E. Johnson provided assistance in the field and laboratory. C.H. Thorman provided valuable suggestions, and we thank H.E. Cook for an extensive, critical review of the manuscript. Mr. F. Egbert and his family graciously provided access to their property.

[1]Department of Geology, Milwaukee Public Museum, 800 W. Wells St., Milwaukee, Wisconsin 53233.

[2]Australian Institute of Marine Science, P.M.B. No. 3, Townsville, M.C., Queensland 4810, Australia.

[3]U.S. Geological Survey, MS939, Federal Center, Denver, Colorado 80225.

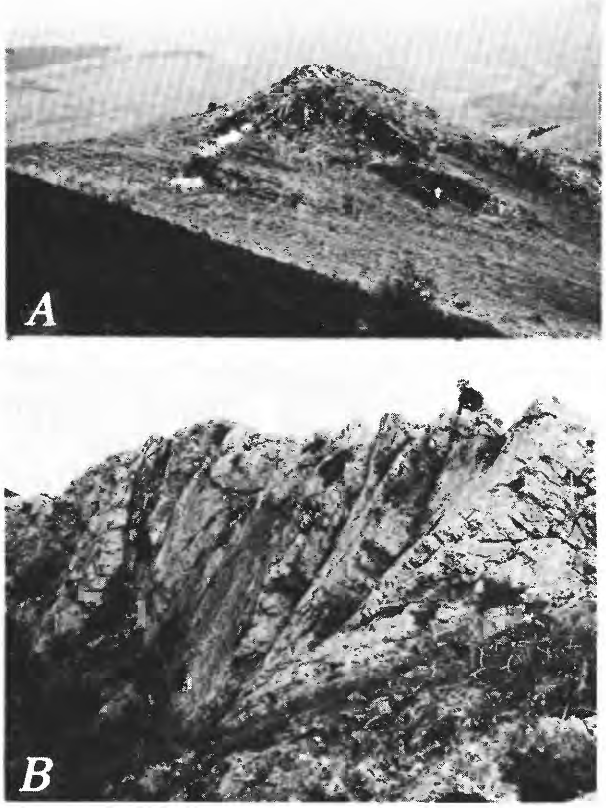


Figure 1. Carbonate body hosted in fine-grained, thin-bedded calcareous turbidites in the Antelope Peak area, northeastern Nevada. A detailed measured section of this 47-m-thick body is given in figure 5. *A*, Beds dip steeply away from viewer; stratigraphically lowest beds are in the foreground; uppermost beds are at the small peak. The resistant carbonate rocks that form the body are surrounded by slope-forming carbonate turbidites. *B*, Upper part of body (shown from a different viewpoint, top to left) composed predominantly of conglomerate and amalgamated T_{ab} turbidite. Upper beds (left) dip more steeply away from body than do lower beds (right).

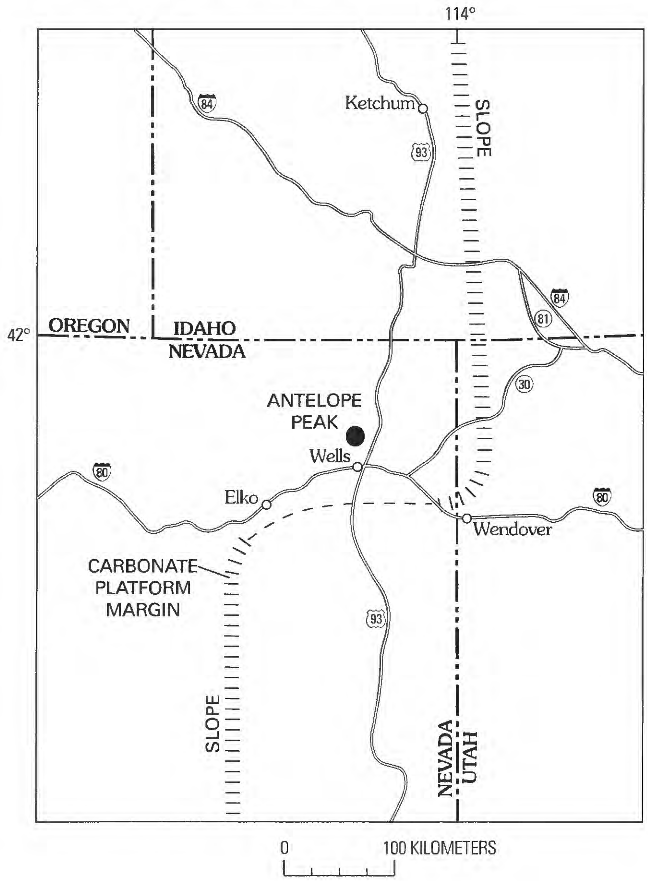


Figure 2. Position of Silurian and Devonian carbonate-platform margin, Antelope Peak area, northeastern Nevada. Dashed where inferred.

GEOLOGIC SETTING

Antelope Peak is in northeastern Nevada, 18 km north of the town of Wells (fig. 2). The sequence of rock strata discussed herein was deposited on a Silurian and Devonian carbonate slope. Thrust faults of Mesozoic age (Ketner, 1984; Smith and others, 1990) transported lower slope and basinal deposits into this region from the northwest. The lower slope deposits are dominated by fine-grained carbonate turbidites and hemipelagic, periplatform ooze. South and east of Antelope Peak shallow-water carbonate shelf deposits are exposed (Johnson and others, 1991; Sheehan and Boucot, 1991).

The Antelope Peak area was first mapped by Peterson (1968), who did not record the carbonate bodies. A detailed map by Smith and others (1983) first recorded the carbonate bodies, which in the map explanation are referred to as possible reefs or debris flows.

Five structural plates are exposed in the Antelope Peak area (Smith and others, 1983). The plates contain rocks ranging from relatively autochthonous platform carbonate strata in the lowest plate to allochthonous slope and basinal deposits in the upper plates (Ketner, 1984; Smith and others, 1990). Structural plate 1 of Smith and others (1990) has been overridden by the other thrust plates.

The stratigraphically lowest rocks exposed in structural plate 1 are shallow-water Devonian dolomite and limestone assigned to the Simonson Dolomite and Guilmette Formation. These strata are younger than those discussed herein and were probably deposited at or very near a seaward-prograding rimmed shelf margin during the Middle and Late Devonian. Rocks of similar lithology are part of a prograding rimmed shelf margin sequence in the nearby Toano Range (Sheehan and Pandolfi, 1983, and our unpublished data). Structural plate 2 consists of thinly laminated limestone of probable Devonian age.

The carbonate bodies described herein are in structural plate 3, which comprises a sequence of Middle Ordovician to Devonian rocks (Smith and others, 1990). The Upper Ordovician and Lower Silurian strata of the plate were deposited on a carbonate ramp well beyond the margin of the carbonate platform (Carpenter and others, 1985). In the late Llandoverian the carbonate ramp was disrupted by collapse of the platform margin along presumed listric growth faults (Johnson and Potter, 1975; Sheehan and Pandolfi, 1983; Carpenter and others, 1985; Sheehan, 1986). This episode of faulting ended the carbonate ramp and established a rimmed carbonate shelf margin upslope from the sedimentary rocks of structural plate 3. Subsequent deposition in this plate was in a deep-water slope environment. Ketner (1984) and Carpenter and others (1985) recognized an abrupt facies change in this structural plate between Ordovician through Lower Silurian rocks and Middle Silurian through Devonian rocks. The Ordovician to Lower Silurian interval is characterized by fine-grained, quiet-water, argillaceous carbonate rocks and a lack of gravity-flow deposits and slumps. The Middle Silurian through Devonian interval is characterized by carbonate turbidites and common rotational and translational slumping. Carpenter and others (1985) ascribed the facies change between the two groups of rock to be a result of the episode of regional downfaulting first described by Johnson and Potter (1975).

Rocks of structural plate 4 are basinal facies, including a variety of lower Paleozoic units referred to as western-facies rocks that include quartz sandstone, siltstone, argillite, limestone, and chert (Smith and others, 1990). Silurian and Devonian carbonate rocks in this interval are commonly thinly laminated and contain sporadic starved ripples. These strata were probably deposited by dilute turbidites. Structural plate 5 includes Devonian siliceous rocks of varied, mostly basinal, facies.

REGIONAL GEOLOGIC HISTORY

A rimmed carbonate platform margin (Read, 1982) of Silurian and Devonian age is preserved in central and northern Nevada. Resedimented carbonate strata deposited along the ocean-facing slope produced a line-sourced apron between the platform margin and the basin to the west (Cook and others, 1983; Hurst and Sheehan, 1985; Hurst and others, 1985; Mullins and Cook, 1986). The platform margin and slope are arrayed in a north-south band extending from southern Nevada to near Elko (Johnson and Potter, 1975; Matti and others, 1975; Nichols and Silberling, 1977; Cook and others, 1983; Hurst and Sheehan, 1985; Hurst and others, 1985; Johnson and others, 1991; Sheehan and Boucot, 1991)(fig. 2). Near Elko, this band of rocks turns abruptly eastward and between Elko and Wendover, Utah, it trends east-west (Sheehan, 1986). Beyond Wendover the platform margin turns northward again into central Idaho (fig. 2). Two explanations of the eastward deflection of lithofacies patterns have been proposed, and we disagree as to which of the explanations is correct. Ketner prefers the view that the present northern margin of shallow-shelf deposition is a right-slip fault, or fault zone, that disrupted the original pattern of deposition (Thorman, 1970; Thorman and Ketner, 1979). In this model the north-trending margin between Wendover and central Idaho (fig. 2) was originally aligned with the north-trending margin between southern Nevada and Elko. Sheehan and Pandolfi prefer an alternative model in which the eastward deflection of the shelf margin is an original depositional pattern and the east-west margin marks the carbonate platform edge rather than a right-slip fault (Sheehan, 1979, 1986; Stevens, 1981; Sheehan and Pandolfi, 1983; Miller and others, 1991). Acceptance of one model or the other has little effect, however, on the conclusions presented herein.

The transition from a gently inclined carbonate ramp to a rimmed carbonate shelf margin in Nevada occurred in the Early Silurian (Johnson and Potter, 1975; Sheehan, 1979, 1986; Sheehan and Pandolfi, 1983; Carpenter and others, 1985; Hurst and others, 1985). Sediments deposited on the slope during the remainder of the Silurian and the Early Devonian have been assigned to the regionally extensive Roberts Mountains Formation and a number of more local formations (Cook, 1983; Johnson and Murphy, 1984; Hurst and Sheehan, 1985; Johnson and others, 1991; Sheehan and Boucot, 1991).

In central Nevada, autochthonous deposits comprising the Lone Mountain Dolomite at the edge of the carbonate shelf margin prograde basinward over the slope; however, the structural plate of this study was originally sufficiently seaward on the slope such that the prograding Lone Mountain Dolomite did not reach it. As a result, sedimentary rocks ranging in age from Middle Silurian well into Devonian are of lower slope facies in this plate.

The Silurian and Devonian carbonate platform margin in northern Nevada generally was a rimmed shelf with carbonate-sand shoals and possible patch reefs. Deposits on the upper slope are dominated by very fine grained, periplatform ooze, and slump features are common (Sheehan and Pandolfi, 1983; Hurst and Sheehan, 1985; Mullins and Cook, 1986). On the inner apron, coarse-grained sediments deposited in turbidity flows and some debris flows alternate with periplatform ooze (Sheehan and Pandolfi, 1983; Hurst and Sheehan, 1985; Mullins and Cook, 1986).

In general, coarse-grained sediments on inner aprons commonly bypass the upper slope by means of gravity transport along numerous parallel, line-source channels that dissect the fine-grained sediments of the upper slope

(Mullins and Cook, 1986). Such channels have not been identified in the upper slope of Nevada, but coarse-grained inner apron sediments resemble material that must have bypassed the upper slope through channels.

Generally, in the outer apron the gravity-flow deposits are progressively finer grained down the slope. Between the outer apron and the basin, thin-bedded, very fine grained, platy limestone is composed of base-cutout carbonate turbidite alternating with periplatform carbonate ooze. The allochthonous carbonate strata that comprise the carbonate bodies described herein probably were deposited in such an intermediate environment. The depositional environment was assigned to the basin plain by Mullens and Cook (1986); however, we assign it to the distal margin of the apron because distal turbidites are dominant here, whereas true basinal deposits dominated by argillite are present in more basinal settings preserved in structurally higher plates 4 and 5.

Deposition of the carbonate bodies on the outermost apron in structural plate 3 was markedly different from the gravity-flow deposition that was common on the inner apron. Coarse sediments on the inner apron bypassed the fine-grained sediments of the upper slope and formed apron-shaped deposits. Each of the carbonate bodies was formed, however, by a series of gravity-flow deposits that accumulated *at one place* on the basin margin, having bypassed the fine-grained upper slope facies, the coarse-grained inner apron facies, and most of the fine-grained outer apron facies.

THE CARBONATE SLOPE AT ANTELOPE PEAK

LOWER PART OF THE ROBERTS MOUNTAINS FORMATION

The Roberts Mountains Formation in structural plate 3 is about 450 m thick (Peterson, 1968). The stratigraphically lower part of the formation is composed of gray limestone sequences of thick amalgamated T_{ab} Bouma sequences interbedded with intervals of complete T_{a-e} turbidites and repetitive, thin, platy, calcareous T_{b-d} sequences (fig. 3*A*). Fossils collected from the lower part of the formation range in age from late Llandoverian to Early Devonian (Smith and others, 1990).

The Devonian beds in the upper part of the lower unit of the Roberts Mountains Formation are well exposed because the calcarenite of the T_a and T_b units is resistant to weathering. The turbidites consist of amalgamated T_a and T_{ab} units interbedded with complete T_{a-e} sequences (figs. 3, 4*A*–*C*). The T_a units are normally graded and contain some shells; commonly, they are normally graded echinoderm grainstone. Individual T_a and T_{ab} calcarenite beds are lens shaped and laterally discontinuous. Individual beds commonly thin from several centimeters to 1 or 2 cm over lateral distances of 10–20 cm.

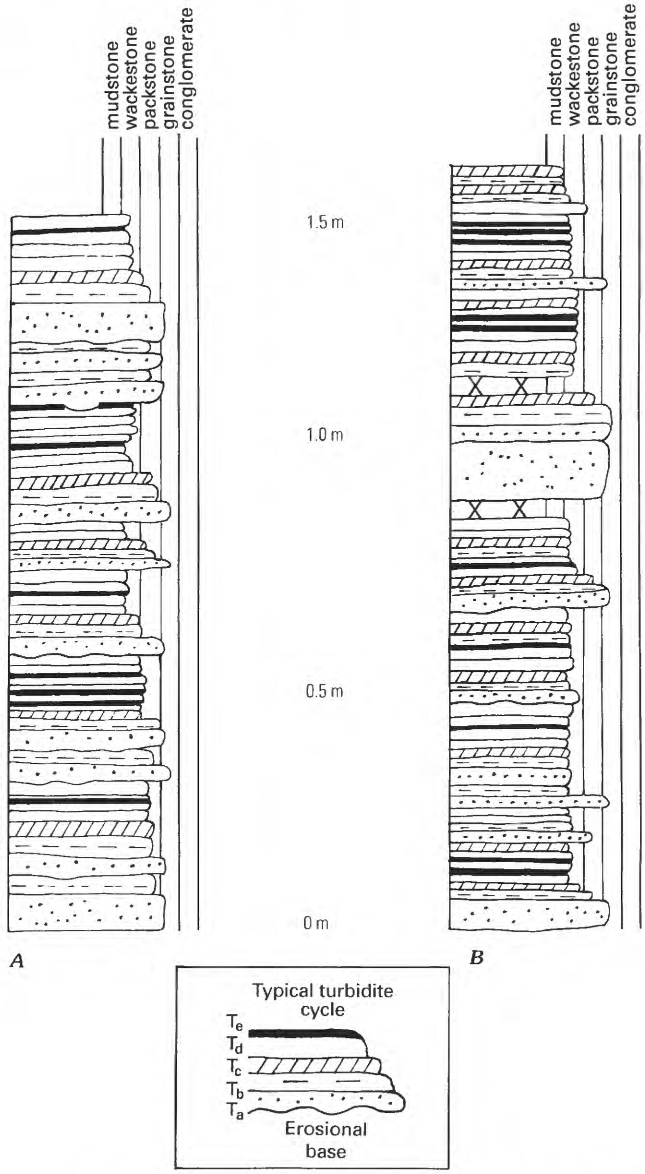
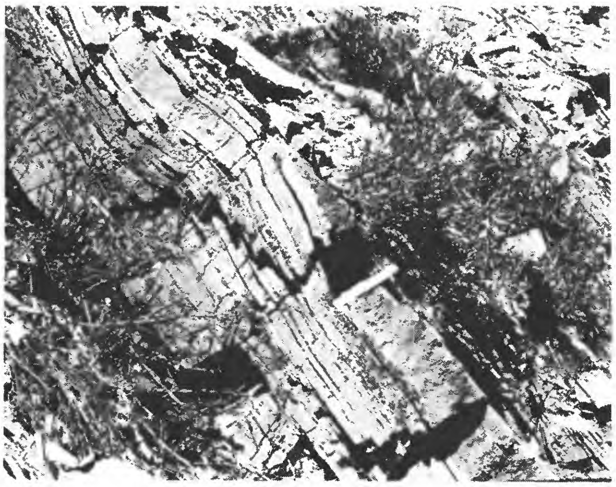


Figure 3. Sediment logs of slope deposits that dominate the Roberts Mountains Formation in structural plate 3 of Smith and others (1990). Reddish-purple pelagic sedimentary rocks commonly cap the T_e units, but, because they are less than 1 mm thick, they are not recorded in these logs. The carbonate bodies of the Antelope Peak area are enclosed within these platy weathering sedimentary strata. *A*, Lower part of formation. *B*, Upper part of formation.

Bases of T_a divisions fill scours in the underlying beds. Soft-sediment deformation features such as flame structures are common where a T_a unit rests on fine-grained carbonate rocks (fig. 4*C*). Similar load features



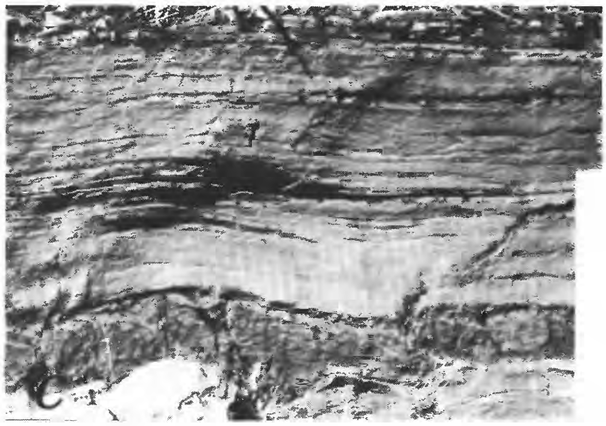


Figure 4 (above and facing column). Calcareous slope turbidites, Antelope Peak area, northeastern Nevada. Scale is 15 cm long. *A*, Lower part of Roberts Mountains Formation. Scale rests on a T_a unit. Note small-scale translational slump. *B*, Bouma T_{a-c} turbidite, lower part of Roberts Mountains Formation. Basal T_a unit about 3 cm thick is overlain by a 2-cm-thick, T_b unit that is locally scoured below the T_c unit. *C*, Lower part of the Roberts Mountains Formation. Dark interval near bottom of photograph is a 2-cm-thick T_a unit; note soft sediment deformation at base. The T_a unit is overlain by a 1.5-cm-thick T_b unit and a 1.5-cm-thick T_c unit, then repetitions of amalgamated T_{b-e} and T_{c-e} units. *D*, Thin-bedded turbidites, upper part of the Roberts Mountains Formation. This outcrop is from below the largest carbonate body described in figure 5 and is typical of sedimentary rocks that enclose the bodies.

are common in carbonate turbidite sequences (Markello and Read, 1981; Cook and others, 1983; Hurst and Surlyk, 1983).

In situ pelagic sediments deposited between turbidity flow events consist of 1-mm-thick fine silt and clay strata. The pelagic strata are seldom more than 1 mm thick and are commonly distinguished by a bright-reddish-purple color (5R4/4). Very thin pelagic units between turbidite beds are consistent with a distal carbonate slope position in the Paleozoic, when little carbonate pelagic material was present. James and Mountjoy (1983) noted that during the Paleozoic there were few calcareous plankton and most fine-grained basinal carbonate sediment was derived from the shallow-water shelf and deposited seaward near the shelf margin.

UPPER PART OF THE ROBERTS MOUNTAINS FORMATION

The upper part of the Roberts Mountains Formation is very platy limestone, with thin T_{ab} turbidites and a predominance of thin, parallel and wavy laminated, platy weathering T_{c-e} units (fig. 3*B*, 4*D*). Fossils from the upper part of the formation are of Early Devonian age (Smith and others, 1990). The carbonate bodies described herein are in strata assigned to the upper part of the Roberts Mountains Formation; corals in one body have been dated as Early Devonian in age (Smith and others, 1990).

The upper part of the Roberts Mountains Formation is less well exposed than the lower part because thin, recessive weathering, platy limestone dominates the sequence. The tannish color of the upper part of the formation reflects noncarbonate argillaceous content. Most of the section is composed of T_{c-e} sequences that are 2–5 mm thick (fig. 3). Amalgamated T_a and T_{ab} sequences are present but are thinner and less common than in the lower part of the Roberts Mountains Formation (figs. 3,4*D*). Although some T_a units are as thick as 30 cm, most are only 1–2 cm thick and many are only a few millimeters thick. Bases of T_a units are scoured and commonly exhibit load structures. Well-rounded, normally graded bioclasts (commonly echinoderm grains) less than 1 mm in diameter characterize the T_a units. Rounded lithoclasts are less common than bioclasts. Bouma T_{a-e} units contain fine, rounded bioclasts or are pelleted. Reddish-purple hemipelagic and periplatform sediments are similar to those in the lower part of the formation. Tilted 3–10-m-thick blocks of platy, laminated sediment at several outcrops are probably the result of rotational slumping. Translational slides from 5 cm to 1 m in thickness are present in less than 1 percent of the sequence (figs. 4*A*, *C*). Sporadic translational slides can be traced laterally into thin debris-flow units, similarly to those described by Cook and Taylor (1977), Cook (1979) and Cook and others (1983).

The sediments, primary sedimentary structures, and slump structures in the upper part of the Roberts Mountains Formation are all characteristic of deposition on an outermost apron. Complete Bouma T_{a-e} turbidites, thin, amalgamated T_{ab} units, and thick sequences of platy, calcareous T_{b-e} and T_{c-e} units are common on the outer apron of a carbonate slope (Walker, 1978; McIlreath and James, 1979; Read, 1982; Cook and others, 1983; Mullins and others, 1984; Mullins and Cook, 1986). Small slumps such as are present in the study area are common in thin-bedded outer slope sequences (Cook and Taylor, 1977; McIlreath and James, 1979; Cook and others, 1983).

SETTING OF THE ROBERTS MOUNTAINS FORMATION

In the Antelope Peak area, upper slope deposits are not exposed; however, in the Toano Range, 60 km to the east, Silurian turbidites and conglomerates of inner apron sequences are overlain by prograding, fine-grained deposits of the upper slope (Sheehan and Pandolfi, 1983).

A variety of shallow-water lithic limestone clasts and clasts of solitary corals, colonial corals, pelmatozoans, and bryozoans are in the matrix-supported conglomerate of the carbonate bodies. Because the clasts were derived from the rimmed shelf margin, they provide an indication of the types of organisms inhabiting that shallow-water environment.

Strata of structural plate 3 are interpreted to have a deepening-upward pattern; the upper part of the lower unit of the Roberts Mountains Formation is made up of coarser grained, thicker turbidites that are made up of more common amalgamated T_a and T_{ab} sequences than in the upper unit of the formation.

The carbonate bodies were deposited in the outermost apron, adjacent to a deep basin. Regional patterns and the upward-deepening sequence of sediments in structural plate 3 (see fig. 8) indicate that progressively upslope from the carbonate bodies are (1) an outer apron made up of predominantly thin bedded, fine-grained carbonate turbidites, (2) an inner apron of conglomerate and turbidites that are thicker bedded and coarser grained than those lower on the slope, (3) an upper slope of fine-grained, hemipelagic and periplatform carbonate sediments in an area that was being bypassed by coarse-grained material, and (4) the shelf margin made up of shallow-water carbonate deposits from which the clasts in the carbonate mounds were being derived.

THE ISOLATED CARBONATE BODIES

Five carbonate bodies mapped by Smith and others (1990) range from about 120 m in width and 10 m in height to about 600 m in width and 47 m in height. The largest bodies are composed of as many as 150 matrix-supported conglomerate units alternating with less common, thick-bedded turbidite units. The upper beds of the carbonate bodies dip away from the center of the bodies, suggesting a moundlike shape. The carbonate bodies are encased in fine-grained, thin-bedded carbonate turbidites that weather to covered slopes (fig. 1). In addition, the carbonate bodies are at different stratigraphic horizons and therefore are not erosional remnants of a single layer.

The exposures do not permit the exact shape of the carbonate bodies to be determined. Upper beds dip away from the centers of the bodies, but the exposures of the bases of the bodies are inadequate to determine whether the bases are flat or concave.

The largest body is depicted graphically in figure 5. Individual conglomerate beds contain large, unsorted, matrix-supported clasts (figs. 5–7). In order of relative abundance, clasts are angular lithic limestone fragments (35 percent), broken bases of fused pelmatozoan stems (30 percent), colonial corals (20 percent), bryozoans (5 percent), and solitary corals (5 percent). Lithoclasts are of a variety of shallow-water lithologies (figs. 6, 7) including carbonate mudstone, cryptalgal laminite, wackestone, and crossbedded grainstone. The massive morphology of many of the colonial corals is characteristic of high-energy environments.

The bases of the conglomerate beds within the isolated carbonate bodies are scoured into the underlying beds. Large clasts commonly project above the tops of the

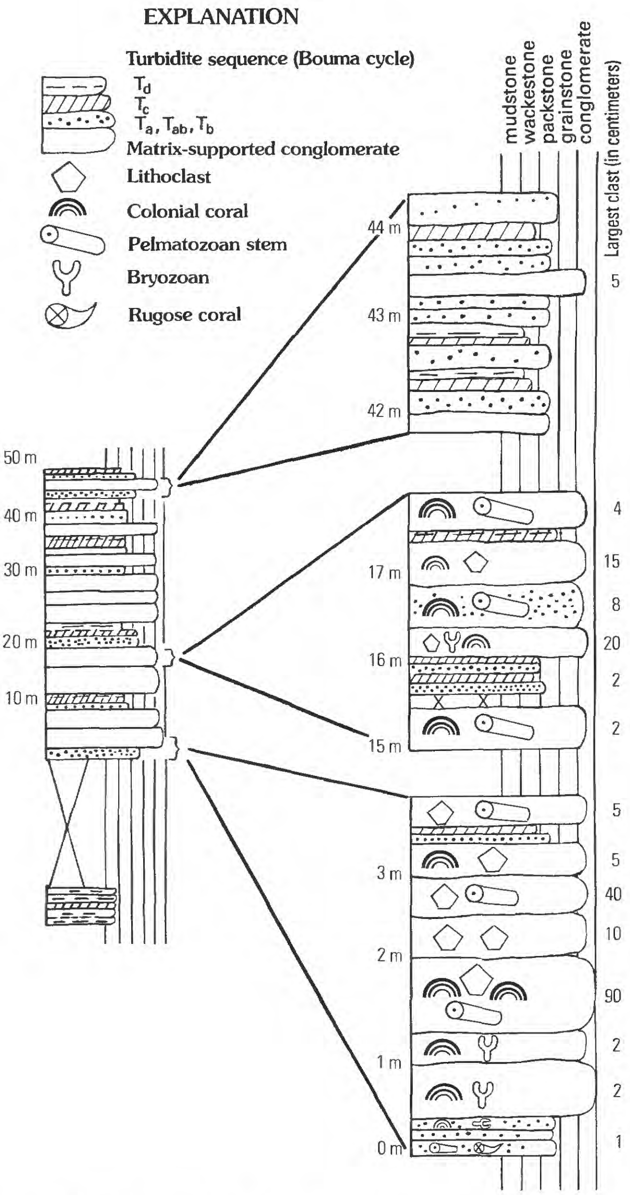


Figure 5. Sediment log of the largest carbonate body in the Antelope Peak area, northeastern Nevada. Photographs of this body are shown in figures 1 and 6. The sediment log was made beginning at the southeast corner of the carbonate body mapped by Smith and others (1990) in the SW¼ sec. 29, T. 40 N., R. 62 E. The log of the entire body is shown on the left, and three parts of body are shown on the right.

conglomerate beds. A few conglomerates grade upward into T_{ab} Bouma divisions. The conglomerate beds are progressively thinner bedded and finer grained upward (table 1). A few conglomerate units contain imbricated clasts; however, directions of imbrication vary greatly from one unit to the next, and no consistent pattern of orientation was found.

In the lower parts of the bodies the turbidites between conglomerates are primarily grain supported, calcareous

Table 1. Thickness of matrix-supported conglomerate beds and size of largest clasts in four intervals in the carbonate body described in figure 5.

[Note that the thickness of conglomerate beds and the size of the largest clasts decrease upward in the body]

Height above base of body (meters)	Thickness of conglomerate bed (centimeters)	Size of largest clast in interval (maximum dimension, centimeters)
35–40	5–21	11
25–30	5–36	18
10–15	10–55	30
0–5	10–90	90

graded T_a units and amalgamated T_{ab} and T_{ac} turbidites. Clasts in the T_a units are much smaller than those in the conglomerates. Turbidites in the middle and upper parts of the bodies include some $T_{a\text{–}e}$ sequences (fig. 5) in addition to T_a and T_{ab} units. Turbidites are more common in the upper parts of the bodies than near the bases. At the base of the measured section is a sequence of amalgamated T_a and T_{ab} turbidites that have much larger clasts than are common in T_a units of the upper part of the formation.

The strata that enclose the bodies are poorly exposed, as is typical of the platy upper part of the Roberts Mountains Formation; however, 20 m below the largest body is a typical basin-margin sequence composed of very thin bedded, platy weathering, argillaceous-carbonate turbidites (figs. 4*D*, 5). Similar argillaceous-carbonate turbidites are lateral to, and overlying, the various bodies.

ORIGIN OF THE ISOLATED CARBONATE BODIES

The Lower Devonian carbonate bodies in the Antelope Peak area were built by repeated depositional events that brought coarse, shallow-water-derived clasts into very localized areas near the basin margin. Most of the conglomerate beds contain chaotic, matrix-supported clasts, scoured bases, and irregular tops with clasts projecting above the tops of the units. The conglomerates are interpreted to be debris-flow deposits. Some beds have imbricate clasts, which is consistent with grain interaction in a turbulent flow (Davies and Walker, 1974; Walker, 1975). In general, disorganized conglomerate beds that have Bouma T_a and T_{ab} units at their tops are consistent with the presence of turbidity currents in the waning phase of a debris flow (Cook and others, 1972; Hampton, 1972; Krause and Oldershaw, 1979).

The allochthonous material making up the carbonate bodies is interpreted to have been derived from point

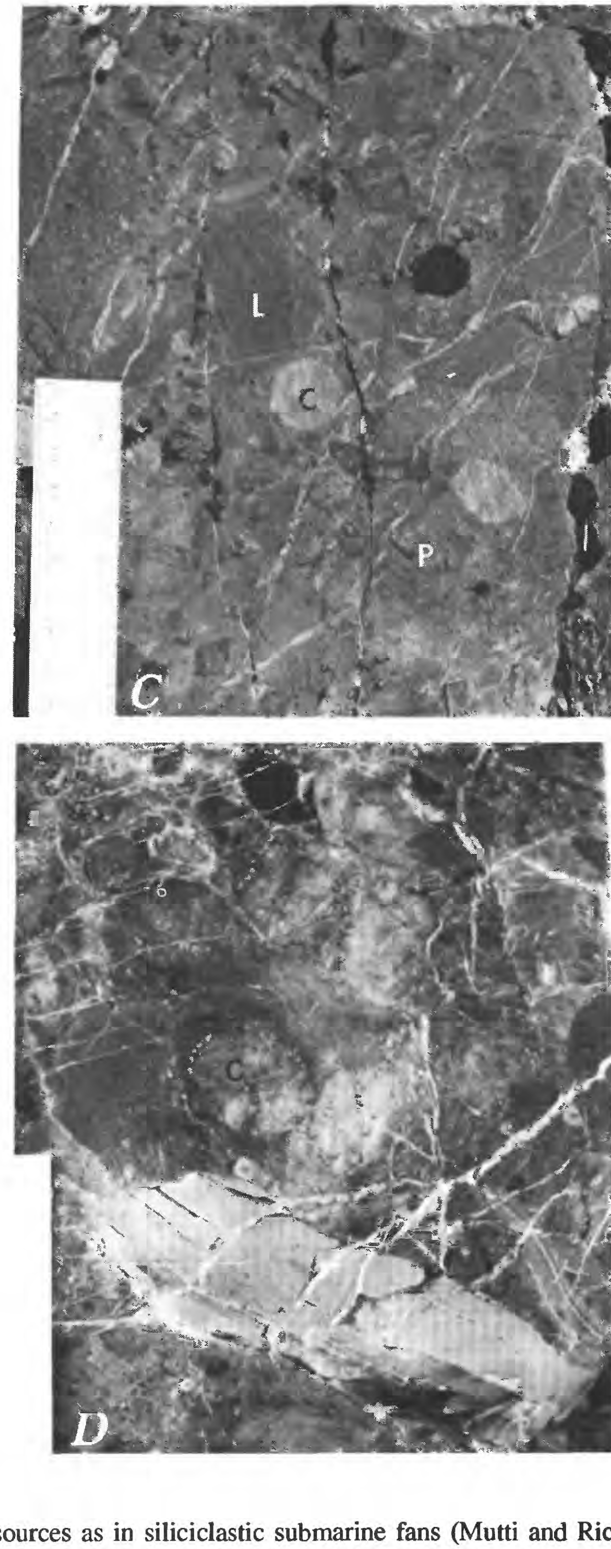


Figure 6 (above and facing column). Matrix-supported, disorganized conglomerates from the largest body in the Antelope Peak area, northeastern Nevada. The conglomerates are interpreted to have been deposited by repeated debris flows. Sediment logs of the body are shown in figure 5. *A*, Angular to subangular margins of limestone clasts. Note that the three almost vertical clasts in lower right of photograph appear to fit together. Pelmatozoan stem bases are common in upper left of photograph. Photograph taken 2 m above base of body. Scale 4 cm. *B*, Pelmatozoan stem bases (P), and subangular lithic clasts (L). Note centimeter-scale banding of lithic clast in left-center of photograph. Lower part of mound. Scale 15 cm. *C*, Angular limestone clasts (L), isolated pelmatozoan columnals (P), and spherical tabulate coral colonies (C). Middle part of body. Scale 9 cm. *D*, Lithic limestone clasts of varied lithology including dark, blocky mudstone clasts (top of photograph), light-colored elongate mudstone (bottom), and tabular, possibly cryptalgal laminite (lower right). Spherical tabulate corals (C) are partially silicified at their margins. Photograph taken 6 m above base of section. Scale 15 cm.

sources as in siliciclastic submarine fans (Mutti and Ricci Lucchi, 1978; Normark, 1978; Walker, 1978). As many as 150 separate debris flows were involved in the formation of the largest bodies. The debris-flow units are thinner and finer grained upward in the bodies, and turbidites are dominant near the tops of the bodies (fig. 5). These features may reflect deflection of debris flows laterally as the bodies grew in size.

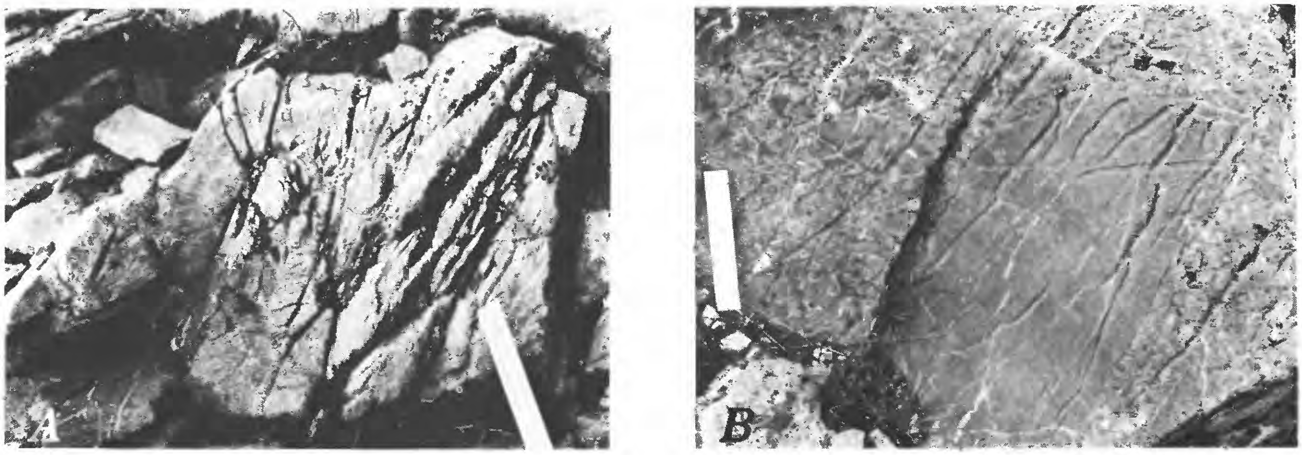


Figure 7. Large clasts from matrix-supported conglomerates in largest carbonate body in the Antelope Peak area (figs. 5, 6). Scale 15 cm. *A*, Clast of colonial tabulate coral, 45-cm-diameter, from 3.0 m above the base of the body. *B*, Angular limestone clast, 60 cm in maximum diameter, from 2.6 m above base of body. Mudstone matrix contains many small lithic clasts such as those adjacent to the scale.

Debris-flow deposits are uncommon in this part of the basin margin except those in the carbonate bodies. Isolated debris-flow deposits also are present in the upper part of the Roberts Mountains Formation on Antelope Peak, but as noted previously they are thin and are composed of slope-derived lithoclasts rather than clasts generated in shallow water on the shelf. Thick debris-flow deposits are present in the lower part of the Roberts Mountains Formation in the Toano Range (Sheehan and Pandolfi, 1983), but they are discrete and laterally extensive units on the inner apron, a position much farther up the carbonate slope than the debris-flow deposits of Antelope Peak. Debris-flow deposits are also present in the Roberts Mountains Formation in central Nevada (Matti and others, 1975; Matti and McKee, 1977; Hurst and Sheehan, 1985; Hurst and others, 1985), but, again, these units are stratigraphically isolated, sheetlike sequences that do not form distinct, compact bodies. Most debris-flow deposits in central Nevada are associated with a prograding, accretionary rimmed-shelf margin in shallowing-upward sequences located high on the slope (Hurst and others, 1985). The debris-flow deposits of Antelope Peak are thus a unique feature on the Silurian to Devonian slope in the Great Basin.

It is not possible to exclude the possibility that the carbonate bodies were deposited as channel fillings because poor exposure does not allow the shape of the bases of the carbonate bodies to be adequately studied. However, because the upper beds dip away from the centers of the bodies, it is more likely that the carbonate bodies are *mounds* that were deposited at the mouths of channels rather than *in* channels. In addition, the coarse nature of the gravity-flow deposits makes it likely that flowage continued through the channels and that deposition occurred at the mouths of the canyons.

In the study area debris-flow conglomerate deposits are present only in carbonate bodies where they are stacked one upon another. They are not present as isolated, single, unstratified deposits. Emplacement of numerous flows at one downslope location requires derivation from a point source and would be likely to occur if the flows were confined by a canyon incised in the upper slope (fig. 8). Clasts may have been fed into such a canyon by longshore currents or storms moving parallel with the coast, although the angularity of most clasts makes extensive transport unlikely. Canyons are common on the upper parts of modern carbonate slopes (Schlager and Chermak, 1979; Mullins and others, 1984), but they produce the line-sourced sediments of the upper apron (Schlager and Chermak, 1979; Cook and others, 1983; Mullins and others, 1984; Mullins and Cook, 1986). In the Antelope Peak area, which was below the upper apron, a few larger, longer canyons may have been the route through which repeated debris flows from the carbonate shelf margin bypassed the inner slope and apron. Thus, we believe that the outer slope carbonate bodies on Antelope Peak were formed from point sources by repeated stacking of debris-flow deposits, probably at the mouths of canyons.

REFERENCES CITED

Carpenter, R.M., Pandolfi, J.M., and Sheehan, P.M., 1985, The Late Ordovician and Silurian of the eastern Great Basin, part 5, two transects across the Upper Ordovician carbonate ramp in eastern Nevada and northwestern Utah: Milwaukee Public Museum, Contributions in Biology and Geology 58, 92 p.

Cook, H.E., 1979, Ancient continental slope sequences and their value in understanding modern slope development: Society of

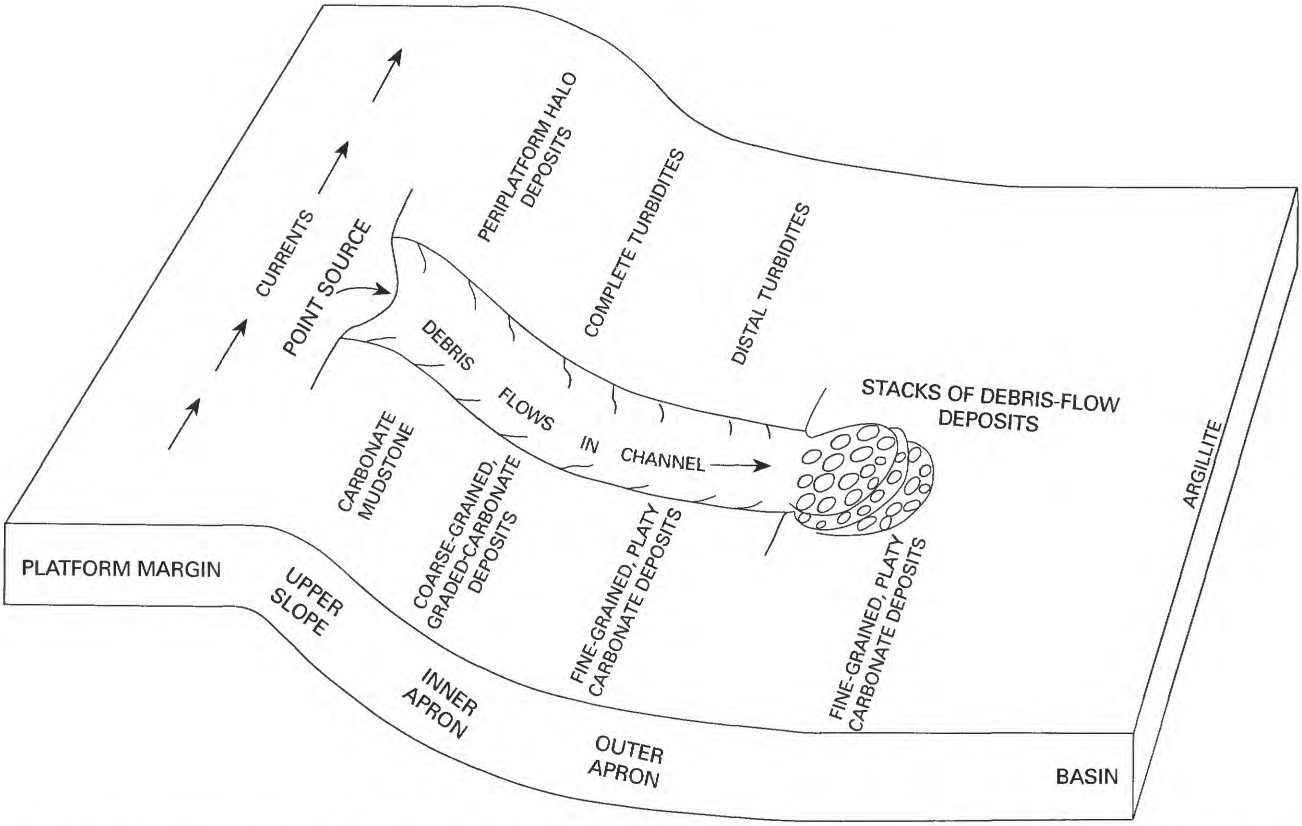


Figure 8. Reconstruction of the Devonian platform to basin transition in the Antelope Peak area. The stacks of conglomerate beds form isolated carbonate bodies in the dominantly fine grained platy carbonate deposits of the outer apron. The conglomerates are interpreted to have been derived from the platform and transported to the apron-basin margin by debris flows. The conglomerates are not present as solitary beds on the outer apron but rather as stacks of numerous individual conglomerates, and a point source feeding into a channel is indicated for each body. No actual channels have been identified, however, on either the slope or apron.

Economic Paleontologists and Mineralogists Special Publication 27, p. 287–305.

———1983, Ancient carbonate platform margins, slopes, and basins: Society of Economic Paleontologists and Mineralogists Short Course Notes 12, 189 p.

Cook, H.E., and Egbert, R.M., 1981, Late Cambrian–Early Ordovician continental margin sedimentation, central Nevada, *in* Taylor, M.E., ed., Proceedings, 2nd International Symposium on the Cambrian System: U.S. Geological Survey Open-File Report 81–743, p. 50–56.

Cook, H.E., McDaniels, P.M., Mountjoy, E.W,. and Pray, L.C., 1972, Allochthonous carbonate debris flows and Devonian bank (reef) margins, Alberta: Canadian Petroleum Geology Bulletin 20, p. 439–497.

Cook, H.E., and Mullins, H.T., 1983, Basin margin environment, *in* Scholle, P.A., Bebout, D.G., and Moore, C.H., eds., Carbonate depositional environments: American Association of Petroleum Geologists Memoir 33, p. 539–617.

Cook, H.E., Mullins, H.T., and Hine, A.C., 1983, Platform margin and deep-water carbonates: Society of Economic Paleontologists and Mineralogists Short Course Notes 12, 573 p.

Cook, H.E., and Taylor, M.E., 1977, Comparison of continental slope and shelf environments in the Upper Cambrian and lowest Ordovician of Nevada: Society of Economic Paleontologists and Mineralogists Special Publication 25, p. 51–81.

Davies, I.C., and Walker, R.G., 1974, Transport and deposition of resedimented conglomerates—The Cap Enrage Formation, Gaspe, Quebec: Journal of Sedimentary Petrology, v. 44, p. 1200–1216.

Hampton, M.A., 1972, The role of subaqueous debris flows in generating turbidity currents: Journal of Sedimentary Petrology, v. 42, p. 775–793.

Hurst, J.M., and Sheehan, P.M., 1985, Depositional environments along a carbonate shelf to basin transect in the Silurian of Nevada: Sedimentary Geology, v. 45, p. 143–171.

Hurst, J.M., Sheehan, P.M., and Pandolfi, J.M., 1985, Silurian carbonate shelf and slope evolution in Nevada—A history of faulting, drowning and progradation: Geology, v. 13, p. 185–188.

Hurst, J.M., and Surlyk, F., 1983, Depositional environments along a carbonate ramp to slope transition in the Silurian of Washington Land, North Greenland: Canadian Journal of Earth Science, v. 20, p. 473–499.

James, N.P., and Mountjoy, E.W., 1983, Shelf-slope break in fossil carbonate platforms—An overview, *in* Stanley, J.D., and Moore, G.T., eds., The shelfbreak—Critical interface on continental margins: Society of Economic Paleontologists and Mineralogists Special Publication 33, p. 189–206.

Johnson, J.G., and Murphy, M.A., 1984, Time-rock model for Siluro-Devonian continental shelf, western United States: Geological Society of America Bulletin, v. 95, p. 1349–1359.

Johnson, J.G., and Potter, E.C., 1975, Silurian (Llandovery) downdropping of the western margin of North America: Geology, v. 3, p. 331–334.

Johnson, J.G., Sandberg, C.A., and Poole, F.G., 1991, Devonian lithofacies of western United States, *in* Cooper, J.D., and Stevens, C.H., eds., Paleozoic paleogeography of the Western United States II: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 67, p. 83–105.

Ketner, K.B., 1984, Recent studies indicate that major structures in northeastern Nevada and the Golconda thrust in north-central Nevada are of Jurassic or Cretaceous age: Geology, v. 12, p. 483–486.

Krause, F.F., and Oldershaw, A.E., 1979, Submarine carbonate breccia beds—A depositional model for two layer, sediment gravity flows from the Sekwi Formation (Lower Cambrian), Mackenzie Mountains, Northwest Territories, Canada: Canadian Journal of Earth Science, v. 16, p. 189–199.

Markello, J.R., and Read, J.F., 1981, Carbonate ramp-to-deeper shale shelf transitions of an Upper Cambrian intrashelf basin, Nolichucky Formation, southwest Virginia Appalachians: Sedimentology, v. 28, p. 573–597.

Matti, J.C., and McKee, E.H., 1977, Silurian and Lower Devonian paleogeography of the outer continental shelf of the Cordilleran miogeocline, central Nevada, *in* Stewart, J.H., Stevens, C.H., and Fritsche, A.E., eds., Paleozoic paleogeography of the western United States, Paleogeography Symposium 1: Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 181–215.

Matti, J.C., Murphy, M.A., and Finney, S.C., 1975, Silurian and Lower Devonian basin and basin-slope limestones, Copenhagen Canyon, Nevada: Geological Society of America Special Paper 159, 48 p.

McIlreath, I.A., and James, N.P., 1979, Accumulation of a Middle Cambrian, deep-water, basinal limestone adjacent to a vertical, submarine carbonate escarpment, southern Rocky Mountains, Canada: Society of Economic Paleontologists and Mineralogists Special Publication 25, p. 113–134.

Miller, D.M., Repetski, J.E., and Harris, A.G., 1991, East-trending Paleozoic continental margin near Wendover, Utah, *in* Cooper, J.D., and Stevens, C.H., eds., Paleozoic paleogeography of the western United States—II: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 67, p. 439–461.

Mullins, H.T., 1983, Base-of-slope carbonate aprons—An alternative to the submarine fan model: American Association of Petroleum Geologists Bulletin, v. 67, p. 521.

Mullins, H.T. and Cook, H.E., 1986, Carbonate apron models—Alternatives to the submarine fan model for paleoenvironmental analysis and hydrocarbon exploration: Sedimentary Geology, v. 48, p. 37–79.

Mullins, H.T., Heath, K.C., Van Buren, H.M., and Newton, C.R., 1984, Anatomy of a modern open-ocean carbonate slope—Northern Little Bahama Bank: Sedimentology, v. 31, p. 141–168.

Mutti, Emiliano, and Ricci Lucchi, Franco, 1978, Turbidites of the northern Appennines—Introduction to facies analysis: International Geological Review, v. 20, p. 987–1035.

Nichols, K.M., and Silberling, N.J., 1977, Depositional and tectonic significance of Silurian and lower Devonian dolomites, Roberts Mountains and vicinity, east-central Nevada, *in* Stewart, J.H., Stevens, C.H., and Fritsche, A.E., eds., Paleozoic paleogeography of the western United States, Paleogeography Symposium 1: Pacific Section, Society of Economic Paleontologists and Mineralogists, p. 217–240.

Normark, W.R., 1978, Fan valleys, channels, and depositional lobes on modern submarine fans—Characters for recognition of sandy turbidite environments: American Association of Petroleum Geologists Bulletin, v. 62, p. 912–931.

Peterson, B.L., 1968, Geology of Antelope Peak, southern Snake Mountains, Elko County, Nevada: Eugene, University of Oregon, M.S. thesis, 78 p.

Read, J.F., 1982, Carbonate platforms of passive (extensional) continental margins—Types, characteristics and evolution: Tectonophysics, v. 81, p. 195–212.

Ruiz-Ortiz, P.A., 1983, A carbonate submarine fan in a fault-controlled basin of the Upper Jurassic, Beltic Cordillera, southern Spain: Sedimentology, v. 30, p. 33–48.

Schlager, W., and Chermak, A., 1979, Sediment facies of platform-basin transition, Tongue of the Ocean, Bahamas: Society of Economic Paleontologists and Mineralogists Special Publication 27, p. 193–208.

Sheehan, P.M., 1979, Silurian continental margin in northern Nevada and northwestern Utah: University of Wyoming Contributions to Geology, v. 17, p. 25–35.

———1986, Late Ordovician and Silurian carbonate-platform margin near Bovine and Lion Mountains, northeastern Utah: Milwaukee Public Museum, Contributions to Biology and Geology, Late Ordovician and Silurian of the eastern Great Basin, part 7, no. 70, 16 p.

Sheehan, P.M., and Boucot, A.J., 1991, Silurian paleogeography of the western United States, *in* Cooper, J.D., and Stevens, C.H., eds., Paleozoic paleogeography of the western United States, II: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 67, p. 51–82.

Sheehan, P.M., and Pandolfi, J.M., 1983, Upper Ordovician–Silurian deposition at the shelf-slope boundary in northern Nevada: Geological Society of America, Abstracts with Programs, v. 15, p. 305.

Smith, J.F., Ketner, K.B., Hernandes, G.X., Harris, A.G., and Smith, M.C., 1983, Preliminary geologic map of the Summer Camp quadrangle and part of the Black Butte quadrangle, Elko County, Nevada: U.S. Geological Survey Open-File Report 83–537, scale 1:24,000.

———1990, Geologic map of the Summer Camp quadrangle and part of the Black Butte quadrangle, Elko County, Nevada:. U.S. Geological Survey Miscellaneous Investigations Map I–2097, scale 1:24,000.

Stevens, C.H., 1981, Evaluation of the Wells fault, northeastern Nevada and northwestern Utah: Geology, v. 9, p. 534–537.

Thorman, C.H., 1970, Metamorphosed and nonmetamorphosed Paleozoic rocks in the Wood Hills and Pequop Mountains, northeast Nevada: Geological Society of America Bulletin, v. 81, p. 2417–2448.

Thorman, C.H., and Ketner, K.B., 1979, West-northwest strike-slip faults and other structures in allochthonous rocks in central and eastern Nevada and western Utah: Rocky Mountain Association of Geologists and Utah Geological Association, Basin and Range Symposium, 1979, p. 123–133.

Walker, R.G., 1975, Generalized facies models for resedimented conglomerates of turbidite association: Geological Society of America Bulletin, v. 86, p. 737–748.

———1978, Deep-water sandstone facies and ancient submarine fans—Models for exploration for stratigraphic traps: American Association of Petroleum Geologists Bulletin, v. 62, p. 932–966.

Wright, V.P., and Wilson, R.C.L., 1984, A carbonate submarine fan sequence from the Jurassic of Portugal: Journal of Sedimentary Petrology, v. 54, p. 394–412.

Published in the Central Region, Denver, Colorado
Manuscript approved for publication February 5, 1993
Cartography by Norma Maes
Photocomposition by Shelly A. Fields
Edited by Judith Stoeser

☆U.S. GOVERNMENT PRINTING OFFICE: 1993-774-049/66063

SELECTED SERIES OF U.S. GEOLOGICAL SURVEY PUBLICATIONS

Periodicals

Earthquakes & Volcanoes (issued bimonthly).
Preliminary Determination of Epicenters (issued monthly).

Technical Books and Reports

Professional Papers are mainly comprehensive scientific reports of wide and lasting interest and importance to professional scientists and engineers. Included are reports on the results of resource studies and of topographic, hydrologic, and geologic investigations. They also include collections of related papers addressing different aspects of a single scientific topic.

Bulletins contain significant data and interpretations that are of lasting scientific interest but are generally more limited in scope or geographic coverage than Professional Papers. They include the results of resource studies and of geologic and topographic investigations; as well as collections of short papers related to a specific topic.

Water-Supply Papers are comprehensive reports that present significant interpretive results of hydrologic investigations of wide interest to professional geologists, hydrologists, and engineers. The series covers investigations in all phases of hydrology, including hydrology, availability of water, quality of water, and use of water.

Circulars present administrative information or important scientific information of wide popular interest in a format designed for distribution at no cost to the public. Information is usually of short-term interest.

Water-Resources Investigations Reports are papers of an interpretive nature made available to the public outside the formal USGS publications series. Copies are reproduced on request unlike formal USGS publications, and they are also available for public inspection at depositories indicated in USGS catalogs.

Open-File Reports include unpublished manuscript reports, maps, and other material that are made available for public consultation at depositories. They are a nonpermanent form of publication that maybe cited in other publications as sources of information.

Maps

Geologic Quadrangle Maps are multicolor geologic maps on topographic bases in 7 1/2- or 15-minute quadrangle formats (scales mainly 1:24,000 or 1:62,500) showing bedrock, surficial, or engineering geology. Maps generally include brief texts; some maps include structure and columnar sections only.

Geophysical Investigations Maps are on topographic or planimetric bases at various scales, they show results of surveys using geophysical techniques, such as gravity, magnetic, seismic, or radioactivity, which reflect subsurface structures that are of economic or geologic significance. Many maps include correlations with the geology.

Miscellaneous Investigations Series Maps are on planimetric or topographic bases of regular and irregular areas at various scales; they present a wide variety of format and subject matter. The series also includes 7 1/2-minute quadrangle photogeologic maps on planimetric bases which show geology as interpreted from aerial photographs. The series also includes maps of Mars and the Moon.

Coal Investigations Maps are geologic maps on topographic or planimetric bases at various scales showing bedrock or surficial geology, stratigraphy, and structural relations in certain coal-resource areas.

Oil and Gas Investigations Charts show stratigraphic information for certain oil and gas fields and other areas having petroleum potential.

Miscellaneous Field Studies Maps are multicolor or black-and-white maps on topographic or planimetric bases on quadrangle or irregular areas at various scales. Pre-1971 maps show bedrock geology in relation to specific mining or mineral-deposit problems; post-1971 maps are primarily black-and-white maps on various subjects such as environmental studies or wilderness mineral investigations.

Hydrologic Investigations Atlases are multicolored or black-and-white maps on topographic or planimetric bases presenting a wide range of geohydrologic data of both regular and irregular areas; the principal scale is 1:24,000, and regional studies are at 1:250,000 scale or smaller.

Catalogs

Permanent catalogs, as well as some others, giving comprehensive listings of U.S. Geological Survey publications are available under the conditions indicated below from USGS Map Distribution, Box 25286, Building 810, Denver Federal Center, Denver, CO 80225. (See latest Price and Availability List.)

"Publications of the Geological Survey, 1879-1961" may be purchased by mail and over the counter in paperback book form and as a set microfiche.

"Publications of the Geological Survey, 1962-1970" may be purchased by mail and over the counter in paperback book form and as a set of microfiche.

"Publications of the U.S. Geological Survey, 1971-1981" may be purchased by mail and over the counter in paperback book form (two volumes, publications listing and index) and as a set of microfiche.

Supplements for 1982, 1983, 1984, 1985, 1986, and for subsequent years since the last permanent catalog may be purchased by mail and over the counter in paperback book form.

State catalogs, "List of U.S. Geological Survey Geologic and Water-Supply Reports and Maps For (State)," may be purchased by mail and over the counter in paperback booklet form only.

"Price and Availability List of U.S. Geological Survey Publications," issued annually, is available free of charge in paperback booklet form only.

Selected copies of a monthly catalog "New Publications of the U.S. Geological Survey" is available free of charge by mail or may be obtained over the counter in paperback booklet form only. Those wishing a free subscription to the monthly catalog "New Publications of the U.S. Geological Survey" should write to the U.S. Geological Survey, 582 National Center, Reston, VA 22092.

Note.–Prices of Government publications listed in older catalogs, announcements, and publications may be incorrect. Therefore, the prices charged may differ from the prices in catalogs, announcements, and publications.

U.S. DEPARTMENT OF THE INTERIOR

MARCH 3, 1849