STATE OF WASHINGTON
DEPARTMENT OF NATURAL RESOURCES
BRIAN J. BOYLE, Commissioner of Public Lands
RUSSELL W. CAHILL, Supervisor

DIVISION OF GEOLOGY AND EARTH RESOURCES
VAUGHN E. LIVINGSTON JR., State Geologist

REPORT OF INVESTIGATIONS
25

A CROSS SECTION OF A NEVADA-STYLE THRUST IN NORTHEAST WASHINGTON

By
J. R. SNOOK,
H. E. LUCAS,
and
M. J. ABRAMS

1981

For sale by Department of Natural Resources, Olympia, Washington
Price .50¢

CONTENTS

ILLUSTRATIONS

A CROSS SECTION OF A NEVADA-STYLE THRUST IN NORTHEAST WASHINGTON

by

J. R. Snook, H. E. Lucas, and M. J. Abrams[1/]

INTRODUCTION

This study is concerned with a cross sectional view across the eastern and central part of the Inchelium 15-minute quadrangle and the northern part of the Dunn Mountain 7½-minute quadrangle, Stevens County, Washington (fig. 1). The study is part of a larger project that involves the preparation of a geologic map of the Inchelium quadrangle (in preparation). The mapping of the Inchelium quadrangle was begun in 1963 by A. B. Campbell (U.S. Geological Survey) and continued in 1971 by J. R. Snook and Eastern Washington University undergraduate and graduate students. A preliminary interpretation of the principal structure in the area and new fossil data, which are very important to workers in this general area, are included in this report.

The cross section as shown on the Index map (fig. 1) extends from the SW. corner of sec. 2, T. 33 N., R. 37 E. east along the section line to the 4600 contour line on the west side of Deadman Hill where the cross section bends southeast and terminates in the NE¼NE¼NE¼ of sec. 13, T. 33 N., R. 38 E.

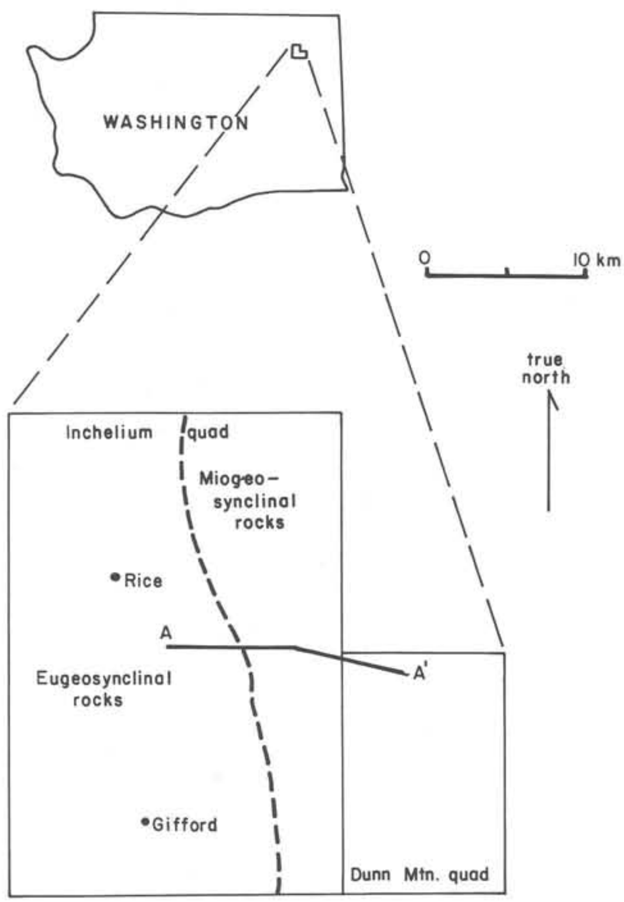

FIGURE 1.—Index map, showing study area, in Stevens County.

GENERAL GEOLOGY

The Inchelium quadrangle lies in a critical position relative to the work which has been done to the north and south. The stratigraphic nomenclature which has been used by Mills (1977), Yates (1964 and 1971), C. D. Campbell (1947), Weaver (1920), and Dings and Whitebread (1965) in areas to the north and northeast does not correspond exactly to that used by Campbell and Raup (1964) in the Hunters quadrangle immediately to the south. The mapping that

1/ Eastern Washington University, Cheney, Washington.

has been completed to the north and northeast can be readily extended south into the Inchelium quadrangle although some of the units are thinner than to the north or change slightly in texture and composition. Thus the nomenclature used in this report does not fit with that used in the Hunters quadrangle by Campbell and Raup (1964). Consequently, it is necessary to recognize the correlation differences to have a uniform picture of the lower Paleozoic in all of northeastern Washington.

The rocks we are concerned with in this study can be divided into two major groups—miogeosynclinal lower Paleozoic quartzites, phyllite/slates, and limestones and eugeosynclinal lower Paleozoic greenstones, graywackes, phyllites (argillites), and discontinuous limestones (figs. 1 and 2). The miogeosynclinal rocks can be correlated with the Addy Quartzite, Maitlen Phyllite, Metaline Limestone, and Ledbetter Slate, either on the basis of lithology and stratigraphic position or in the case of the Ledbetter on reliable fossil evidence. The eugeosynclinal rocks are dated on the basis of a new fossil locality which was discovered by Peter Ward (McMaster University) in 1972.

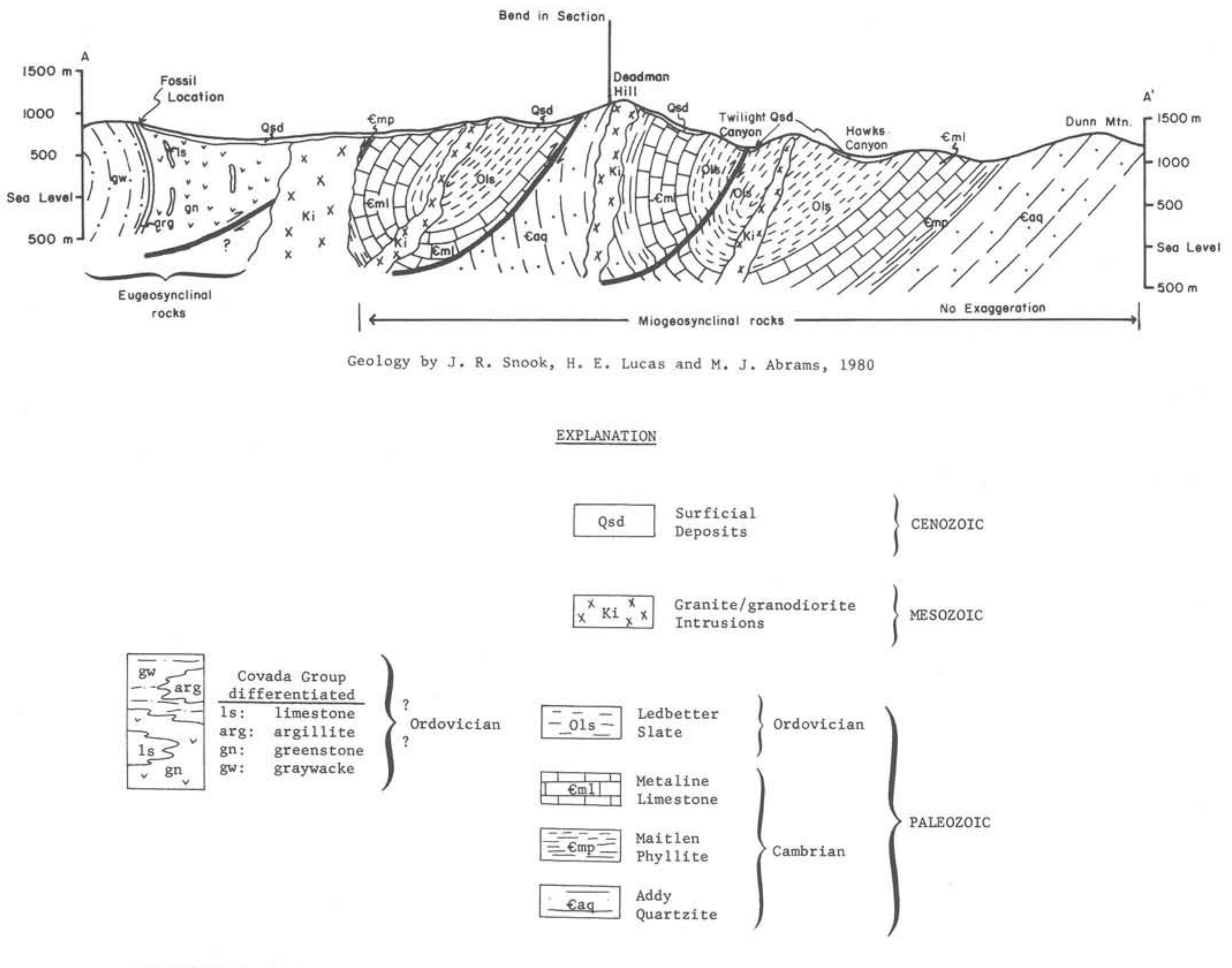

FIGURE 2.—Geologic cross section through parts of the Inchelium and Dunn Mountain quadrangles.

ADDY QUARTZITE

The Addy Quartzite is exposed on Dunn Mountain (Weaver, 1920, p. 62) and Deadman Hill (fig. 2) along the line of the cross section. The bulk of the Addy Quartzite is a light-gray to white, fine- to medium-grained vitreous quartzite. It is well indurated and contains stretched pebble conglomerate beds, less than 3 centimeters (cm) thick, scattered discontinuously throughout the unit. Bedding varies in thickness from several cm to over seven meters (m) and averages 1 m. Sporadic, poorly developed bedding-plane parting is common and imparts an appearance of massive bedding. Small cross bedding and ripple marks are locally common.

The lower middle part of the unit is easily recognized by its purple-banded quartzite. Bedding thickness varies from several millimeters (mm) to 0.5 m. Approximately 300 m above the base and just below the purple quartzite is a section of quartzite and shale interbeds. These interbeds average 20 m thick and are separated by 4-m-thick, light-gray to light-yellow, quartzite beds. The interbeds are generally sandy and most are hematite-rich, which controls their light gray, maroon or light green color.

The Addy and its probable equivalent to the north, the Gypsy Quartzite (Miller and Clark, 1975, p. 27), are ridge-formers throughout northeastern Washington. Park and Cannon (1943, p. 13) describe the thickness of the Gypsy Quartzite as varying between 2,591 and 1,615 m in the Metaline quadrangle. Miller and Clark (1975, p. 28) describe a homoclinal 1,219-m-thick section of Addy Quartzite in the Loon Lake area, and Becraft and Weis (1963, p. 12) report the Addy Quartzite as being 1,189 m thick in the Turtle Lake quadrangle. The estimated thickness in the report area is 1,390 m minimum.

The Addy Quartzite is dated as Early Cambrian by Okulitch (1951) and A. R. Palmer (Miller and Clark, 1975, p. 28). Although there are no known fossils in this unit in the area of study, abundant trace fossils, *Skolithos* (vertical to near vertical dwelling burrows) and *Planolites* (parallel to oblique feeding or locomotion burrows), can be found in argillaceous and shaly interbeds within the upper half of the unit. The unidentified fossils described by Jones (1928) from T. 33 N., R. 38 E., sec. 14, may belong to the Addy Quartzite or Maitlen Phyllite.

MAITLEN PHYLLITE

The Maitlen Phyllite is poorly exposed but is in gradational contact with the Addy Quartzite. The basal contact is placed along a line where quartzite exists only as small stringers.

Four distinct lithologic zones can be recognized: (1) the lower 40 m consists of a gray-green, phyllitic argillite with numerous small stringers of argillaceous quartzite; (2) the next 10 m is a distinctive, light-brown to tan, spotted argillite which owes its spots to oxidation of fine-grained pyrite; (3) the overlying 90 m is a monotonous sequence of gray-green, phyllitic, thin-bedded quartzite; and (4) the top 40 m is a fine-grained, hard, black phyllitic quartzite. While planar features in the lower three zones are primarily cleavage, the top zone retains bedding. Trace fossils such as *Planolites* are common in this zone. Ripple marks are also abundant. Earlier geologic studies (Park and Cannon, 1943; and Mills, 1977) report that the unit thins southward, from 1,524 m thick in the Metaline quadrangle to the 610-m-thick, previously known, southern exposure at the Santiago mine (20 km north of the study area). Miller and Clark (1975, p. 28) describe a 30.5-m-wide interval, between argillaceous limestone of the lowest Metaline and quartzite of the highest Addy, that is covered but which may contain phyllite. This interval, along with the estimated 180 m thickness in the study area, may extend the thinning Maitlen Phyllite southward to Springdale, Washington.

The Maitlen Phyllite is dated as Early Cambrian by Okulitch and Little (Dings and Whitebread, 1965, p. 8). This age is based on fossils which were collected in the basal portion of the Maitlen Phyllite at a locality near the international boundary in the Metaline quadrangle.

METALINE LIMESTONE

The Metaline Limestone, although its contacts are poorly exposed, appears to be gradational with the Maitlen Phyllite. The limestone itself is generally well exposed.

The basal unit of the Metaline Limestone in this area is composed of gray-green thin-bedded limestone. The clay, siltite, and dolomite interbeds common in the thin-bedded limestone grade upward into a sequence of massive blue-gray limestones and subordinate interbeds of dark-gray slate and massive white and black dolomite. The blue-gray limestones range from micrites to sparrudites and grade from pure limestones to dolomitic limestones containing scattered pyrite. The dark-gray slate interbeds range from 2 cm to 15 m in thickness and exhibit bedding plane cleavage. Many of the slate interbeds are calcareous and alternate with thin-bedded limestones that tend to weather more rapidly, leaving a corrugated surface. The massive white dolomite interbeds are 0.5 m to 4 m thick. They are micritic to sparry and very hard. The black dolomite interbeds are similar to the white dolomite interbeds, but contain abundant carbonaceous material.

The middle to upper unit in the Metaline Limestone consists of a massive blue-gray limestone and abundant slate interbeds. Thin black dolomite beds are abundant, and have been described by Harbour (1978) as a characteristic of the middle dolomite unit of the Metaline Limestone.

The blue-gray limestone includes what appears to be oncolites that have been replaced by sparry calcite. Their shape ranges from spheroidal to ellipsoidal, and their size ranges from 1 mm to 4 mm. Similar rocks are also described by Park and Cannon (1943, p. 19). The beds containing these algal structures occur at several stratigraphic intervals in the middle and upper units of the Metaline Limestone.

The Metaline Limestone has been dated by J. Bridge (Park and Cannon, 1943, p. 19) and Okulitch (Dings and Whitebread, 1965, p. 22) as Middle Cambrian. Repetski (1977) has redefined the age of the Metaline Limestone as Middle to Late(?) Cambrian and Early Ordovician on the basis of conodonts and vertebrates found in the upper part of the "Metaline Dolomite." Fossils have not yet been found in the study area.

Park and Cannon (1943, p. 18) have measured 914 meters of Metaline Limestone in the Metaline quadrangle. The thickness in the vicinity of the cross section is approximately 375 m in the west and 900 m in the east. The western thinning may be a structural thinning.

Immediately north of the line of cross section the Metaline is characteristically massive limestone and dolomite. South of this line the unit becomes less dolomitic and increasingly thin bedded. This facies change seems to provide the link between the descriptions of the Metaline Limestone of northern Stevens County and the thin-bedded lithology of the Old Dominion Limestone as it is mapped in the Hunters quadrangle.

LEDBETTER SLATE

The Ledbetter Slate generally forms valleys and low slopes but locally may underlie low hills where it is silicified. It is in conformable and gradational contact with the Metaline Limestone over a 30-m-wide zone.

The Ledbetter Slate consists of thin-bedded fine-grained black slates, gray phyllites, black quartzites, white quartzite pods, and silicified black slates and quartzites. The gray phyllites appear to be black slates that have been bleached by underlying intrusives, which are also responsible for the silicification seen in the slates.

The slates and phyllites are composed entirely of fine-grained quartz and carbonaceous material. The black quartzites are composed of larger, fine sand-sized quartz grains in a matrix of silt-sized quartz grains and carbonaceous material. Pyrite and other opaque metallic minerals are present in minor amounts.

Although Park and Cannon (1943, p. 20) report the unit to be about 762 m thick in the Metaline quadrangle, its thickness was not measured in the area of the cross section because of poor exposure and structural complexities. Much of the deformation produced by folding and faulting has been absorbed by the Ledbetter Slate.

The age of the Ledbetter Slate is Early and Middle Ordovician based on numerous fossils found throughout Stevens County (Park and Cannon, 1943; and Mills, 1977). Fossils found in this study are described in the section on fossils.

COVADA GROUP

The name Covada Group is used in this report because the rocks can be traced westward without interruption (except for Lake Roosevelt) into the Covada Group mapped by Pardee (1918). In the vicinity of the cross section the rocks are primarily graywackes and greenstones, which have lenses and pods of argillite and limestone. A stratigraphic order to these mutually interbedded units has not been recognized at this time.

The graywackes are gray to brown, medium- to coarse-grained sandstones, which are locally conglomeratic. The clasts are mostly quartz, chert, muscovite, and fine-grained rock fragments. Locally the pebbles in the conglomeratic layers are elongate. Argillite layers a few centimeters to a meter or more thick are common in the graywackes. Bedding plane slippage has produced a strong schistosity in the argillites where the rocks have been deformed.

The greenstone in this area is light to dark green and contains abundant calcite-filled fractures and amygdules. Relict plagioclase laths can be discerned in some samples but in strongly deformed areas the rock is a greenschist. Pillow textures occur locally in the bottom of some flow units. Argillite and sandstone layers within the greenstone are normally lenticular and rarely exceed 10 m in thickness. Limestone pods are quite common within the greenstone, attaining thicknesses up to 30 m and lengths to 800 m. The pods are a fine- to medium-grained, equigranular, gray limestone. Fossils have not yet been found within most of the limestone pods in this area, although they have been found in one argillite interbed in the greenstone. On the basis of these fossils, the Covada Group is dated as Early Ordovician (see following section on fossils) at least in the area of this cross section (fig. 2). In other areas the Covada is considered to be Pennsylvanian(?) (Fox and Rinehart, 1974), which indicates that these eugeosynclinal rocks probably span most of the Paleozoic.

FOSSIL LOCALITIES

Four fossil localities in this area provide the only positive stratigraphic proof of the relationship between the Ledbetter Slate and the Covada Group. Three of the sites are in the Ledbetter Slate.

The northernmost Ledbetter Slate collection was from the NW¼NE¼ sec. 24, T. 34 N., R. 37 E. Fossils identified by Reuben J. Ross, Jr. (U.S. Geological Survey, 1975-76, written communication) include the following graptolites:

Climacograptus cf. *C. bicornis*
Glossograptus sp.
Orthograptus 2 spp. (cf. *Calcaratus*)
Dicellograptus sp.
Dicranograptus sp. (cf. *D. nicholsoni*)

According to Ross, the fossils are Early Caradocian (Middle Ordovician) in age. The next locality is in the SE¼SW¼ sec. 6, T. 33 N., R. 38 E. Ross identified *Climacograptus* sp. and *Dicellograptus* sp. which are Caradocian also. The third collecting site is in the NW¼SE¼ sec. 18, T. 33 N., R. 38 E. Graptolites identified by Ross include:

Isograptus caduceus var.
Phyllograptus(?) sp. — (gigantic form)
  or *Glossograptus* sp.

Ross interprets this collection as Llanvirnian (Middle Ordovician) in age.

The Covada Group collecting site is located in the W½SW¼SW¼ sec. 2, T. 33 N., R. 37 E. The fossils are found in a sequence of steeply dipping sandstone, siltstone, and argillite in a zone about 7 m wide within the greenstones. Peter Ward (McMaster University) identified the following forms:

Moxomia n. sp.
Pliomeroides sp. ind.
Geragnostus curvata?
Asaphellus sp.

Ward suggests a Tremadocian (Early Ordovician) age for this fauna, based on his preliminary identification. John Repetski (U.S. Geological Survey, 1977, written communication) has identified conodonts collected by Michael E. Taylor (U.S. Geological Survey) from a limestone just north of this locality in the W½SW¼NW¼SW¼ sec. 2, T. 33 N., R. 37 E. The forms, listed below, indicate an age of medial or late Early Ordovician.

?Acanthodus lineatus (Furnish)
?Clavohamulus sp.
Drepanodus parallelus Branson and Mehl
  s.f.
Drepanodus sp. s.f.
c.f. *Drepanodus arcuatus* Pander (*sensu*
  van Wamel, 1975)
  arcuatiform elements
  graciliform elements
  pipaform elements
c.f. *Drepanoistodus forceps* (Lindstrom)
  (*sensu* van Wamel, 1975)
  acodiform elements
  drepanodiform (*homocurvatus*-type)
    elements
  drepanodiform (*planus*-type) elements
  oistodiform elements
  suberectiform elements
Paroistodus sp.
  drepanodiform elements
Scolopodus filosus Ethington and Clark s.f.
S. gracilis Ethington and Clark
  graciliform element
S. rex Lindstrom
  acodiform element
  acontiodiform element, indet.
  distacodiform element, indet.
  drepanodiform element, indet.

STRUCTURE

The rocks exposed along the line of the cross section (fig. 2) can be divided into two groups (see fig. 1), based on lithology, structure, and age. The western block includes the eugeosynclinal Early Ordovician Covada Group. The eastern block contains the miogeosynclinal Early Cambrian to Middle Ordovician rocks of the Addy Quartzite, Maitlen Phyllite, Metaline Limestone, and Ledbetter Slate. The western block is in contact with the eastern block along a narrow zone which is covered by Quaternary surficial deposits. Thus the nature of the structure separating these two blocks of identical age and dissimilar facies can only be inferred. Since the facies for the early part of the Ordovician are not gradational between the two blocks, it can only be assumed that the crustal shortening necessary to bring the blocks together was along a thrust fault. It has been assumed by many workers including Pardee (1918) that the Covada Group is younger than the Ledbetter Slate and thus the Covada is an unconformable sequence representing a major facies change later in the Paleozoic. This study has shown that at least part of the Covada Group is Early Ordovician. This fact alone necessitates a major structural discontinuity between the two blocks.

The miogeosynclinal rocks (eastern block) dip from 15° to 75° to the west. Based on the repetition of units in an east-west direction, this uniformity in dip direction can only be explained by an overturned syncline (see fig. 2). The direction of overturning is to the east. The Ledbetter Slate is repeated to the west of the principal overturned syncline, which may be interpreted as an imbricate slice associated with the main thrust to the west. Exposures in this area are very poor; most of the bedrock is covered by Quaternary surficial deposits. These north-trending faults are located in valleys which have been excavated by glaciers and streams and as a result they are also covered by unconsolidated sediments.

The eugeosynclinal rocks of the Covada Group dip uniformly to the east and northeast from 35° to 80°. This indicates that the internal structure within the two blocks are quite dissimilar. It may be possible in the near future to unravel the precise style of deformation in the Covada Group. The uniform dip to the east has been interpreted as homoclinal but it may in fact represent an isoclinal style of folding or perhaps numerous repetitive faults. Precise dating of the major thrusting event is not possible at this time, but it is certainly post-Middle Ordovician and pre-intrusive. Most of the intrusives in this area are Cretaceous or early Tertiary. Hopefully, this report will encourage others to look more critically at the Covada Group in the future. Significant crustal shortening of this type between Paleozoic eugeosynclinal and miogeosynclinal rocks has been described by many workers in Nevada and Idaho. The work and bibliographies of Dover (1980) and Ketner (1977) provide a current update on these Nevada-style structures. Not enough detailed work has been done yet to complete the sedimentational and structural history of this area to the same accuracy as Nevada, but we are much closer to an understanding of the structural relationship between northeastern Washington, southern Idaho, and Nevada.

SUMMARY

This report recognizes two different bodies of rock that are presently adjacent along a north-south line that extends through the center of the Inchelium quadrangle. The western block is composed of Early Ordovician eugeosynclinal rocks (Covada Group) that are dipping steeply to the east. The eastern block contains Cambrian through Middle Ordovician miogeosynclinal rocks (Addy Quartzite, Maitlen Phyllite, Metaline Limestone, and Ledbetter

Slate), which are dipping to the west in a series of easterly overturned folds. A major thrust fault is interpreted as the glide horizon, which has brought the eugeosynclinal block eastward into contact with the miogeosynclinal block of comparable age. The eastward migrating allochthonous block helps to account for the eastward overturning in the autochthonous block. The allochthonous block can be traced at least 20 km to the west of the cross section. Both blocks are cut by faults of differing ages; some are probably imbricate faults related to the main thrust. Northwest- and northeast-trending faults are probably post-thrusting. During the Late Cretaceous or early Tertiary, quartz monzonitic intrusive rocks invaded both bodies of rock along small irregular apophyses of larger batholithic bodies at depth. The early Paleozoic depositional history and subsequent thrust faulting is remarkably similar to that found in Nevada.

REFERENCES

Abrams, M. J., 1980, Geology of part of the Inchelium quadrangle, Stevens County, Washington: Eastern Washington University M.S. thesis, 30 p.

Becraft, G. E.; Weis, P. L., 1963, Geology and mineral deposits of the Turtle Lake quadrangle, Washington: U.S. Geological Survey Bulletin 1131, 73 p.

Campbell, A. B.; Raup, C. B., 1964, Preliminary geologic map of the Hunters quadrangle, Stevens and Ferry Counties, Washington: U.S. Geological Survey Mineral Investigations Field Studies Map MF-276, scale 1:48,000.

Campbell, C. D., 1947, Cambrian rocks of northeastern Stevens County, Washington: Geological Society of America Bulletin, v. 58, p. 597-612.

Dings, M. G.; Whitebread, D. H., 1965, Geology and ore deposits of the Metaline zinc-lead district, Pend Oreille County, Washington: U.S. Geological Survey Professional Paper 489, 109 p.

Dover, James H., 1980, Status of the Antler orogeny in central Idaho—Clarifications and constraints from the Pioneer Mountains. In Fouch, T. D.; Magathan, E. R., editors, Paleozoic paleogeography of the west-central United States: Society of Economic Paleontologists and Mineralogists, Rocky Mountain Paleogeography Symposium I, p. 371-386.

Fox, F. K., Jr.; Rinehart, C. D., 1974, Comparison of Anarchist and Covada Groups of north-central Washington. In Geological Survey Research 1974: U.S. Geological Survey Professional Paper 900, p. 50-51.

Harbour, J. L., 1978, The petrology and depositional setting of the Middle Dolomite unit, Metaline Formation, Metaline district, Washington: Eastern Washington University M.S. thesis, 67 p.

Jones, R. H. B., 1928, Notes on the geology of Chewelah quadrangle, Stevens County, Washington: Northwest Science, v. 2, p. 111-116.

Ketner, K. B., 1977, Deposition and deformation of lower Paleozoic western facies rocks, northern Nevada. In Stewart, J. H.; Stevens, C. H.; Fritsche, A. E., editors, Paleozoic paleogeography of the western United States: Society of Economic Paleontologists and Mineralogists, Pacific Coast Paleogeography Symposium I, p. 251-258.

Lucas, H. E., 1980, Geology of part of the Dunn Mountain and Arden 7½-minute quadrangles, Stevens, County, Washington: Eastern Washington University M.S. thesis, 30 p.

Miller, F. K.; Clark, L. D., 1975, Geology of the Chewelah-Loon Lake area, Stevens and Spokane Counties, Washington: U.S. Geological Survey Professional Paper 806, 74 p.

Mills, J. W., 1977, Zinc and lead ore deposits in carbonate rocks, Stevens County, Washington: Washington Division of Geology and Earth Resources Bulletin 70, 171 p.

Okulitch, V. J., 1951, A Lower Cambrian fossil locality near Addy, Washington: Journal of Paleontology, v. 25, no. 3, p. 405-407.

Pardee, J. T., 1918, Geology and mineral deposits of the Colville Indian Reservation, Washington: U.S. Geological Survey Bulletin 677, 186 p.

Park, C. F., Jr.; Cannon, R. S., Jr., 1943, Geology and ore deposits of the Metaline quadrangle, Washington: U.S. Geological Survey Professional Paper 202, 81 p.

Repetski, J. E., 1977, Age of the Metaline Limestone or Formation in northeastern Washington: U.S. Geological Survey Bulletin 1457-A, p. A107.

Weaver, C. E., 1920, The mineral resources of Stevens County: Washington Geological Survey Bulletin 20, 350 p.

Yates, R. G., 1964, Geologic map and sections of the Deep Creek area, Stevens and Pend Oreille Counties, Washington: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-412, scale 1:31,680.

Yates, R. G., 1971, Geologic map of the Northport quadrangle, Washington: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-603, scale 1:31,680.