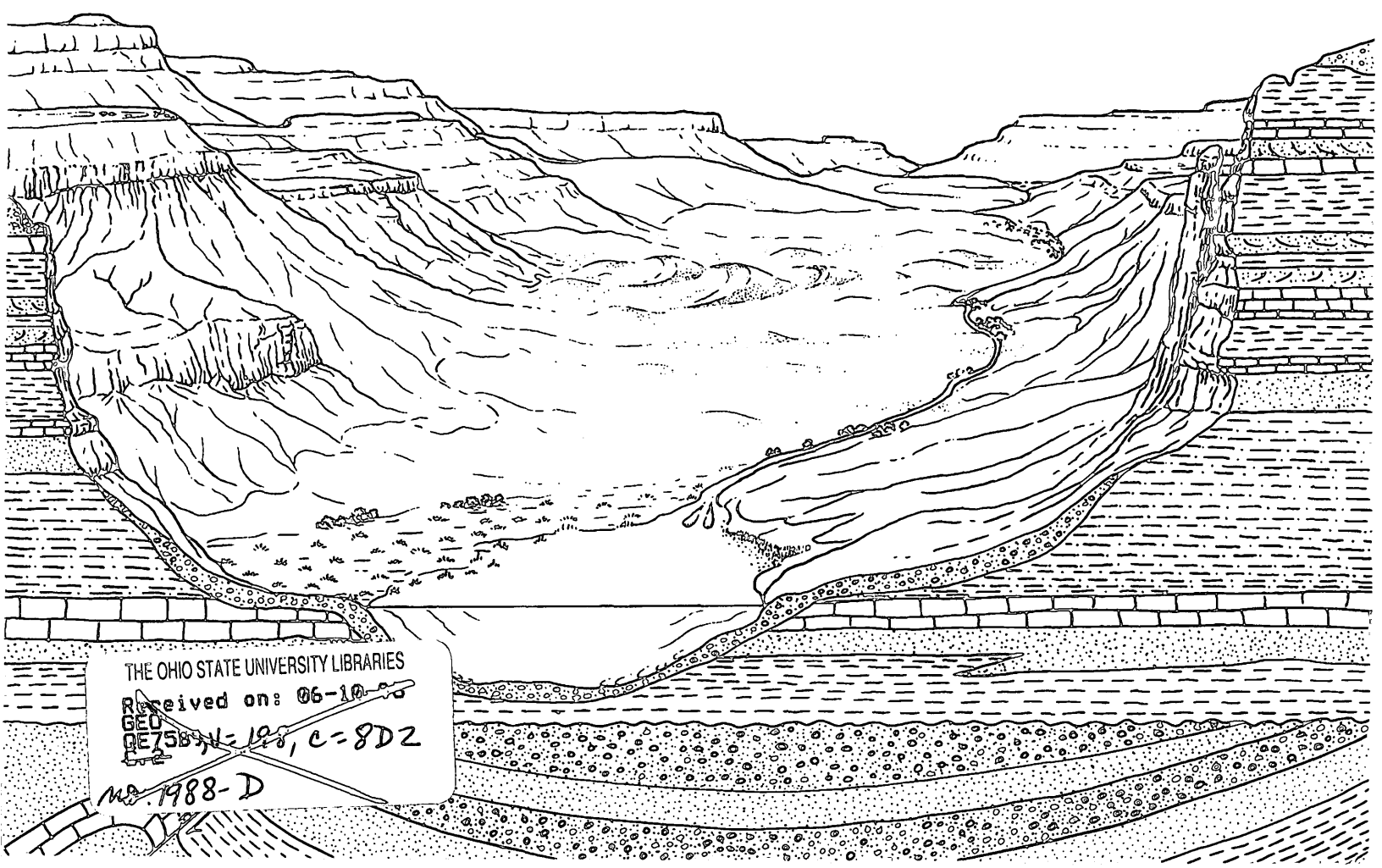
Paleozoic and Mesozoic Rocks of Mount Ichabod and Dorsey Canyon, Elko County, Nevada—Evidence for Post-Early Triassic Emplacement of the Roberts Mountains and Golconda Allochthons

U.S. GEOLOGICAL SURVEY BULLETIN 1988–D



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Paleozoic and Mesozoic Rocks of Mount Ichabod and Dorsey Canyon, Elko County, Nevada—Evidence for Post-Early Triassic Emplacement of the Roberts Mountains and Golconda Allochthons

By KEITH B. KETNER, BENITA L. MURCHEY, ROBERT G. STAMM, *and* BRUCE R. WARDLAW

EVOLUTION OF SEDIMENTARY BASINS—EASTERN GREAT BASIN
HARRY E. COOK and CHRISTOPHER J. POTTER, Project Coordinators

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U.S. GEOLOGICAL SURVEY BULLETIN 1988–D

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
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Library of Congress Cataloging-in-Publication Data

Paleozoic and Mesozoic rocks of Mount Ichabod and Dorsey Canyon, Elko County, Nevada : evidence for post-early Triassic emplacement of the Roberts Mountains and Golconda Allochthons / by Keith B. Ketner ... [et al.]
p. cm. — (Evolution of sedimentary basins—Eastern Great Basin : ch. D.) (U.S. Geological Survey bulletin : 1988–D)
"A multidisciplinary approach to research studies of sedimentary basins, both ancient and modern."
Includes bibliographical references.
Supt. of Docs. no.: I28.3:1988D
1. Geology, Stratigraphic—Paleozoic. 2. Geology, Stratigraphic—Mesozoic. 3. Geology—Nevada—Elko County. 4. Paleontology—Nevada—Elko County. I. Ketner, Keith Brindley, 1921– . II. Series. III. Series: U.S. Geological Survey bulletin : 1988–D.
QE75.B9 1988–D
[QE654]
557.3 s—dc20 93–17176
[551.7'2'0979316] CIP

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By KEITH B. KETNER, BENITA L. MURCHEY, ROBERT G. STAMM, *and* BRUCE R. WARDLAW

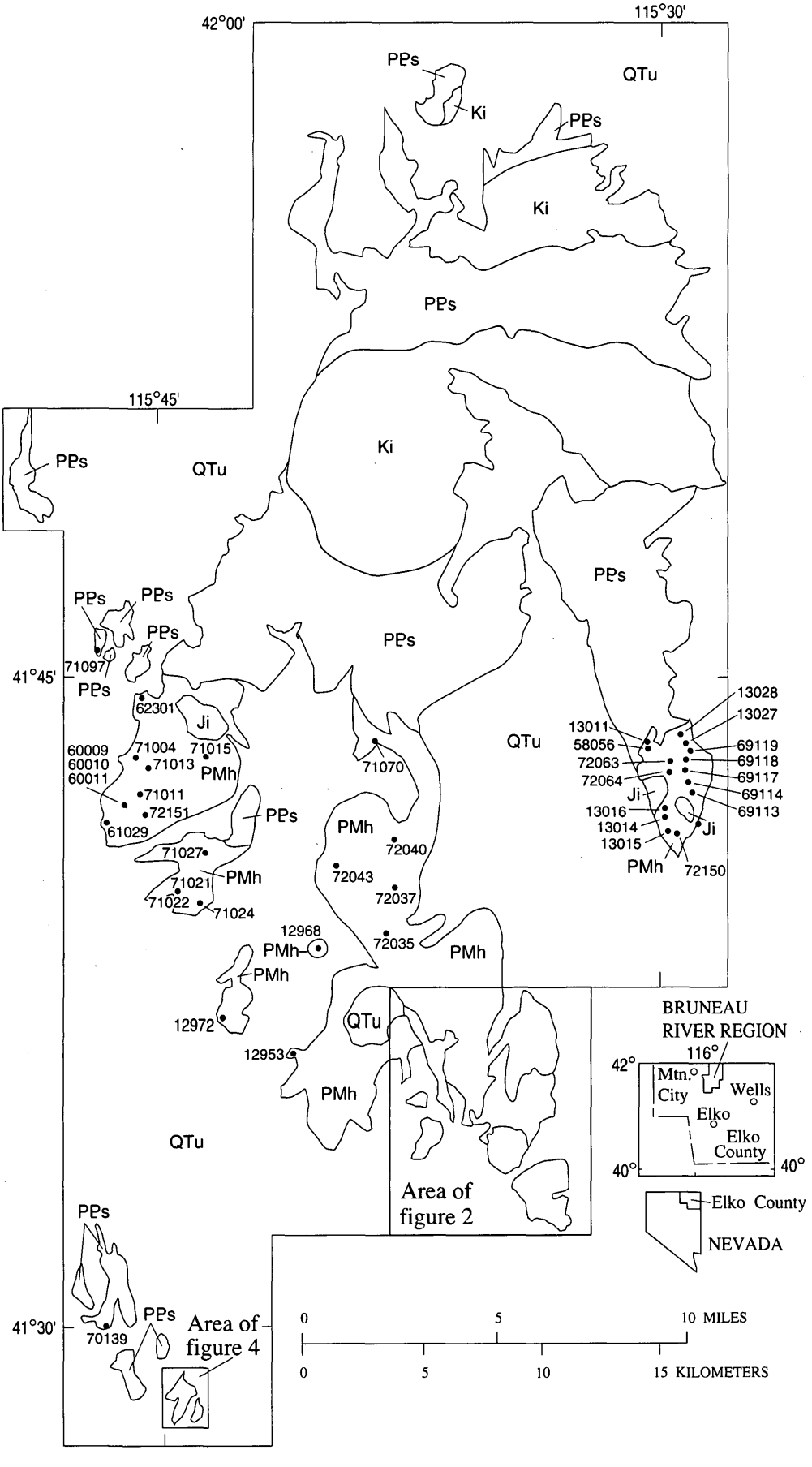
ABSTRACT

In the Mount Ichabod–Dorsey Canyon area of northeastern Nevada the Roberts Mountains allochthon, the overlap assemblage, and the Golconda allochthon are tectonically interlayered with Lower Triassic rocks. The Roberts Mountains allochthon consists of the Ordovician Valmy Formation, composed of quartzite, bedded chert, shale, and argillite, and unnamed Silurian siltstone and chert. The overlap assemblage, a Pennsylvanian and Permian sequence of conglomerate, sandstone, siltstone, limestone, and bedded chert, overlies the Roberts Mountains allochthon unconformably, and parts of it are in thrust fault contact with other structural plates. The Golconda allochthon is composed of the Mississippian to Permian Havallah sequence, a rootless, internally faulted and folded mass of siltstone, argillite, bedded chert, and redeposited limestone. Lower Triassic rocks, here termed the Dolly Creek sequence, are deep-water deposits of limy shale and redeposited argillaceous limestone. The significance of the Mount Ichabod–Dorsey Canyon area is in the unequivocal evidence, afforded by the tectonic interlayering, that both the Golconda and Roberts Mountains allochthons were emplaced after Early Triassic time.

INTRODUCTION

The Bruneau River region (fig. 1), of which Mount Ichabod and Dorsey Canyon are parts, is a tract of hills and canyons in northeastern Nevada just south of the Idaho State line between the Jarbidge Mountains on the east and the Independence and Bull Run Mountains on the west. A large part of the region was first studied from 1952 to 1954 as doctoral dissertations by K.O. Bushnell and J.R. Coash, and their maps and reports were later published as bulletins of the Nevada Bureau of Mines (Bushnell, 1967; Coash, 1967). Revised versions of the geology as described in these bulletins were incorporated into the geologic maps of Elko County (Coats, 1987) and Nevada (Stewart and Carlson, 1978). Most of the sedimentary rocks in the region are deep-water deposits almost devoid of identifiable macrofaunas, and, as a consequence, the age ranges of most of the stratigraphic units are difficult to determine and some are still uncertain. Complex structural relations reflect contractional and extensional tectonic events and multiple igneous intrusive events. Consequently, although both the published maps of Coash and Bushnell and the later revisions are useful, they should be regarded as preliminary and used with great caution. Recent studies of parts of the Bruneau River region (Little, 1987; Schwarz and others, 1991) resulted in improved concepts but leave many important questions unanswered. The present study of the Bruneau River region was begun in 1988 as a long-term effort to definitively date the stratigraphic units, determine their depositional environments, and provide an improved interpretation of the complex structural relations. A geologic map of the Mount Ichabod area at a scale of 1:24,000 (Ketner, 1992) and this report on the Mount Ichabod–Dorsey Canyon area are the first results of that effort.

The early Paleozoic Roberts Mountains allochthon, the overlap assemblage, and the late Paleozoic Golconda allochthon all are present in the Mount Ichabod–Dorsey Canyon area. As commonly understood, the Roberts Mountains allochthon is a tectonic assemblage composed of lower Paleozoic, deep-water, mainly siliceous, sedimentary rocks and volcanic rocks and is underlain by the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72063
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69119
69118
69117
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13016
13014
13015
72150
70139
Area of figure 2
Area of figure 4
BRUNEAU RIVER REGION
116°
42°
40°
Mtn. City
Wells
Elko
Elko County
Elko County
NEVADA
0 5 10 MILES
0 5 10 15 KILOMETERS

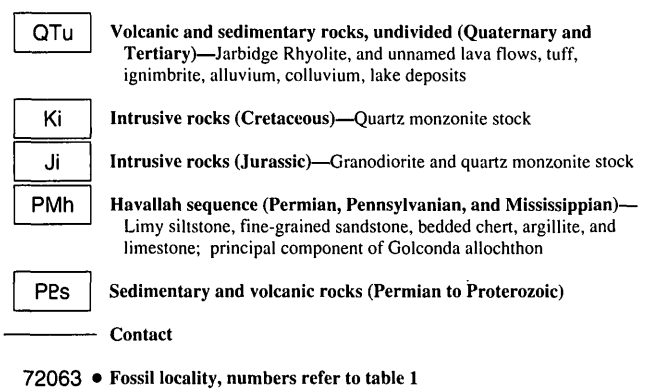


Figure 1 (above and facing page). Geology of the Bruneau River region, northeastern Nevada. Locations of map areas of figures 2 and 4 are also shown.

Roberts Mountains thrust fault. The allochthon generally is considered to be linked with the Antler orogeny and to have been emplaced in latest Devonian to earliest Mississippian time (Roberts and others, 1958; Johnson and Pendergast, 1981).

Upper Paleozoic sequences that disconformably or unconformably overlie the Roberts Mountains allochthon are conventionally termed the overlap assemblage (Roberts and others, 1958). In the Mount Ichabod–Dorsey Canyon area this assemblage is of Late Pennsylvanian and Permian age and consists, from the base upward, of conglomerate, limestone, siltstone and sandstone, and bedded chert. In some other areas of the region, the lowermost beds are of Mississippian age, and the depositional order of lithic units differs somewhat from that in the Mount Ichabod and Dorsey Canyon areas.

As commonly understood the Golconda allochthon is a tectonic assemblage of upper Paleozoic, deep-water, mainly siliceous, sedimentary rocks and volcanic rocks and is underlain by the Golconda thrust fault. The allochthon is generally considered to be linked with the Sonoma orogeny and to have been emplaced in Late Permian or Early Triassic time (Silberling and Roberts, 1962).

In the Mount Ichabod area, the Roberts Mountains and Golconda allochthons and slices of the overlap assemblage are tectonically interlayered with the Lower Triassic Dolly Creek sequence (figs. 2, 3). In this report we describe the strata comprising the allochthons and the Triassic rocks and present evidence that the Paleozoic rocks were emplaced simultaneously by contractional faulting in post-Early Triassic time.

Fossil collections are described in table 1, on pages 8 and 9.

Acknowledgments.—Robert R. Coats and his assistants collected all paleontological samples numbered above 58000 (Coats, 1986). These were examined and dated by the following former members of the U.S. Geological Survey: R.C. Douglass, Mackenzie Gordon, Jr., W.H. Hass, J.W. Huddle, and E.L. Yochelson. Three additional collections were examined and dated by C.A. Sandberg of the U.S. Geological Survey. Suggestions by Edward A. Johnson and Norman J. Silberling, both of the U.S. Geological Survey, greatly improved the content and style of this report.

DESCRIPTIONS AND AGES OF MAP UNITS

ROBERTS MOUNTAINS ALLOCHTHON

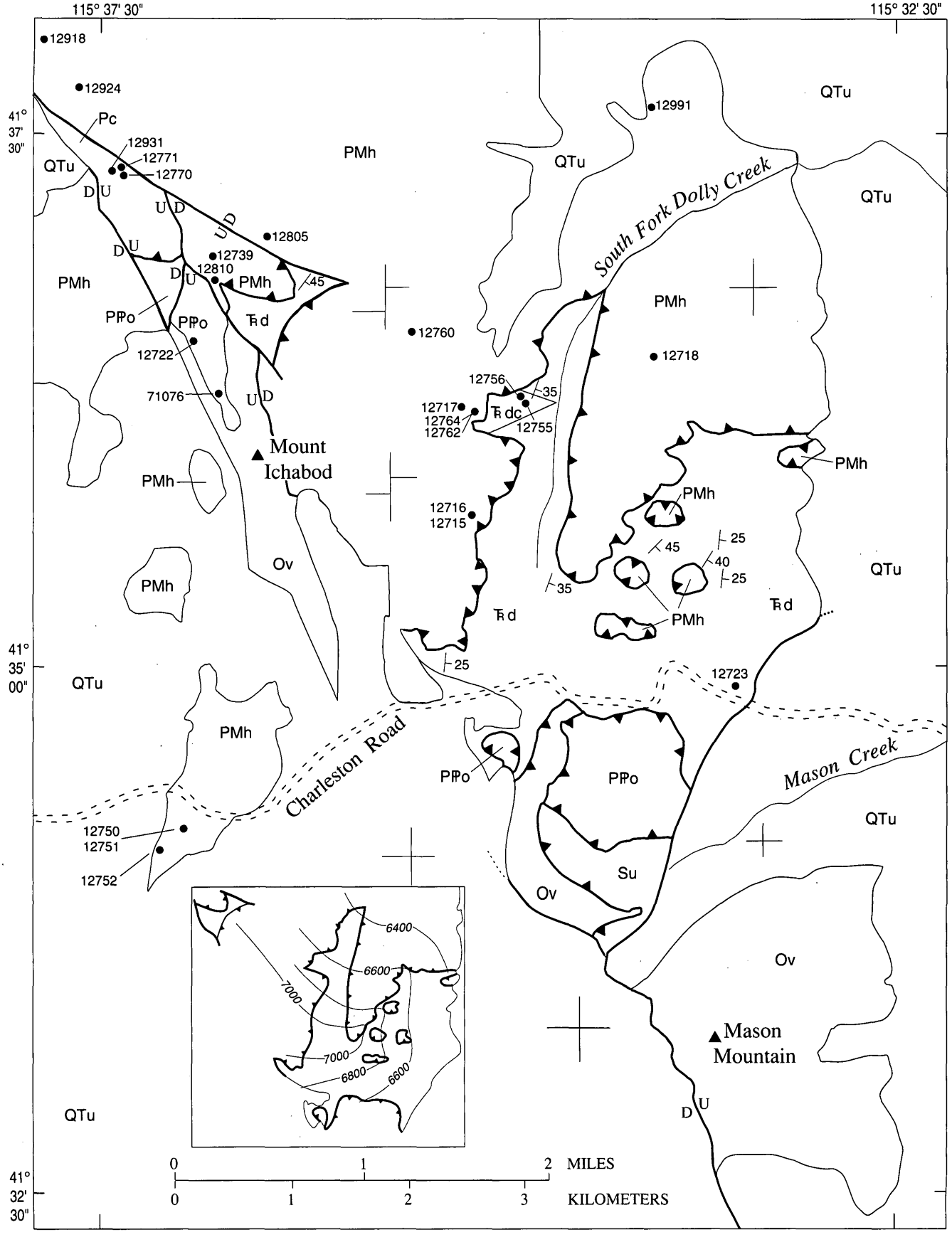
VALMY FORMATION

Exposed parts of the Valmy Formation in the Mount Ichabod–Dorsey Canyon area are composed of orthoquartzite, bedded chert, argillite, and shale. The quartzite is composed almost entirely of silica-cemented medium- to coarse-grained quartz sand. Beds are commonly 3–9 ft (1–3 m) thick and lack such sedimentary structures as grading, sole marks, or cross stratification that might reveal some aspect of depositional conditions. Chert beds are 1 in.–1 ft (2.5–30 cm) thick and tend to be dark gray or black. Shale and argillite, interbedded with quartzite beds, are black and commonly are silty and sandy.

Middle Ordovician conodonts were recovered from the Valmy Formation about 1.5 mi (2.4 km) northwest of the Dorsey Canyon map area (fig. 1). Fossils were not found in the parts of the Valmy exposed within the Mount Ichabod and Dorsey Canyon map areas, and the identity of the formation in these areas is based entirely on lithic similarities with Valmy strata of known age elsewhere. The identification is considered secure, however, because in no other sequence are pure quartzite, bedded chert, and shale or argillite so closely associated. The exposed part of the Valmy at Mount Ichabod is probably several hundred feet thick, but the base and top of the formation are not exposed and internal faulting prevents an accurate measurement of its thickness. In the Rowland area, 20 mi (32 km) north of Mount Ichabod, where the Valmy is better exposed, the Valmy is at least 5,000 ft (1,524 m) thick.

SILURIAN STRATA

Micaceous, feldspathic siltstone and light-colored bedded chert are associated with the Valmy Formation in both the Mount Ichabod and Dorsey Canyon areas. The siltstone displays graded bedding, abundant trace fossils on bedding surfaces, and weathers to tones of greenish gray and tan. The chert is generally very light colored, in contrast to the dark grays and black of chert in the Valmy.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12751
12752
Pc
PMh
QTu
PPo
Trd
Trdc
Ov
Su
45
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25
40
U
D
Mount Ichabod
Mason Mountain
South Fork Dolly Creek
Charleston Road
Mason Creek
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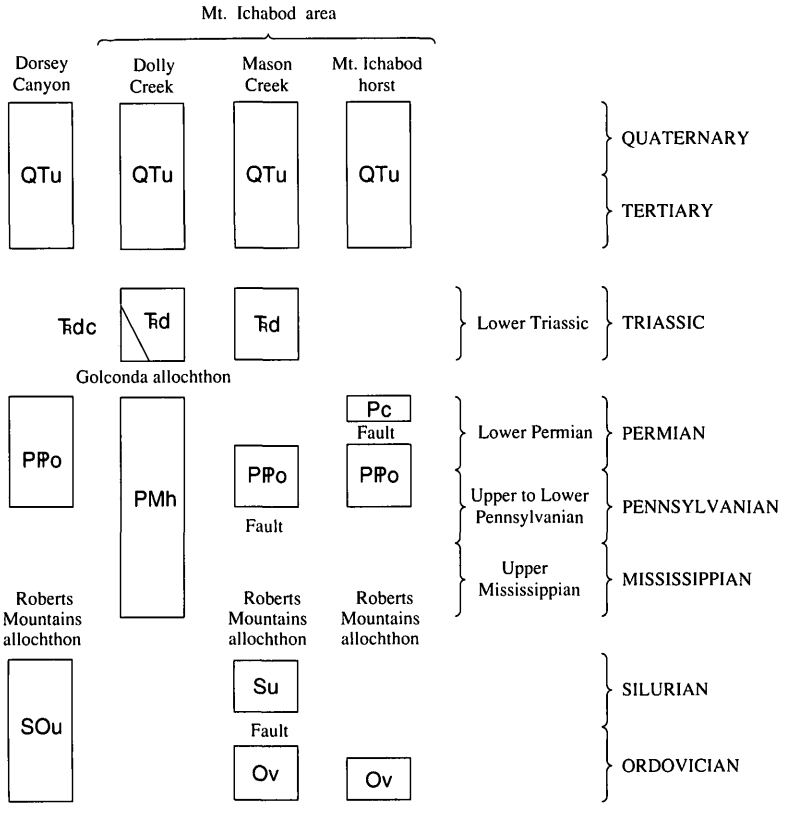
7000
6800
0 1 2 MILES
0 1 2 3 KILOMETERS

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

QTu — **Volcanic and sedimentary rocks, undivided (Quaternary and Tertiary)**—Jarbidge Rhyolite and unnamed lava flows, tuff, ignimbrite, alluvium, colluvium, lake deposits

Trd — **Dolly Creek sequence (Lower Triassic)**—Principally thinly laminated deep-water deposit of limy, argillaceous siltstone, limy sandstone, and silty, argillaceous limestone. Also locally includes a conglomeratic facies (Trdc)

Pc — **Heterogeneous conglomerate (Permian)**—Principally boulder conglomerate; lesser amounts of sandstone, siltstone, and bedded chert; boulders derived from Valmy Formation, overlap assemblage, and Permian phosphatic rocks; presence of Permian phosphatic clasts indicates that unit is younger than the overlap assemblage

PPPo — **Overlap assemblage (Permian and Upper Pennsylvanian)**—Complete sequence consists, in order, of basal conglomerate, limestone, sandstone and siltstone, and phosphatic bedded chert

PMh — **Havallah sequence (Permian, Pennsylvanian, and Mississippian)**—Limy siltstone, fine-grained sandstone, bedded chert, argillite, and limestone; principal component of Golconda allochthon

Su — **Siltstone and chert undivided (Silurian)**—Upper micaceous feldspathic siltstone unit of Middle(?) Silurian age and lower light-colored bedded chert unit of Early(?) Silurian age

Ov — **Valmy Formation (Ordovician)**—Thick-bedded medium- to coarse-grained quartzite, bedded chert, black shale, argillite

Contact

Structure contour— Numbers are feet above sea level

Section corner

High-angle fault—U, upthrown side; D, downthrown side; dotted where concealed

Thrust fault—Sawteeth on upper plate

Strike of beds showing degree of dip

Fossil locality—Number refers to table 1

Figure 2 (above and facing page). Geology of the Mount Ichabod area. The Havallah sequence, representing the Golconda allochthon, and rocks of the Roberts Mountains allochthon overlie Lower Triassic rocks on a thrust fault of low relief. Mount Ichabod is a horst that displays strata underlying the Triassic rocks. Inset map shows structure contours of the thrust fault between Paleozoic and underlying Triassic rocks. Geologic and structure contour maps modified from Ketner (1992).

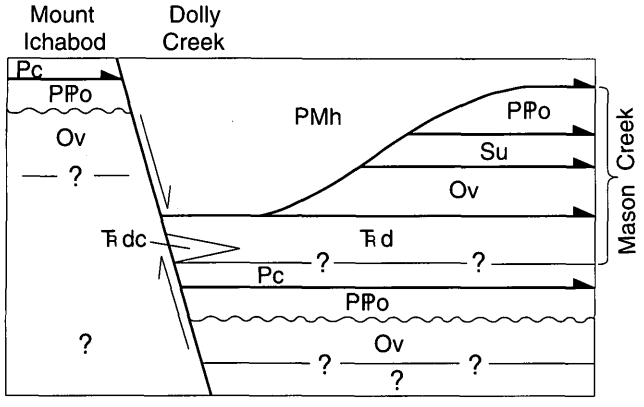


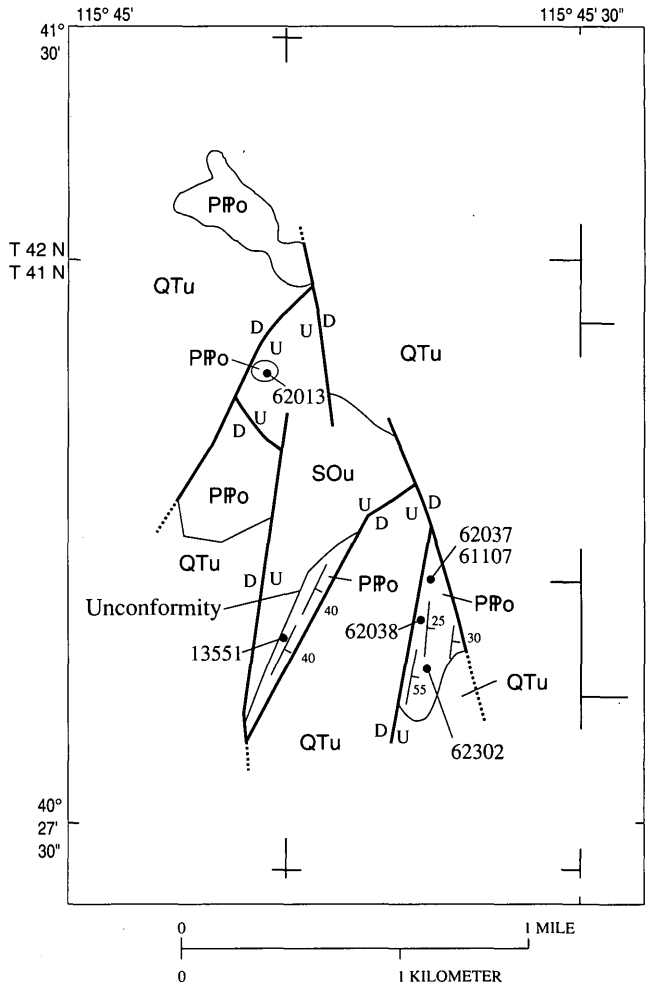
Figure 3. Diagrammatic cross section showing the structure of the Mount Ichabod area as inferred from the geologic relations shown in figure 2 and from regional relations. Stratigraphic units and their letter symbols same as those for figure 2. Not to scale.

Both the chert and the siltstone units are assigned a Silurian age on the basis of lithic resemblance to paleontologically dated strata of Early and Middle Silurian age in the Adobe Range, 30 mi (48 km) to the south (Ketner and Ross, 1990), and elsewhere (Ketner, 1991). The correlation is considered quite reliable because no other abundantly micaceous, feldspathic siltstone associated with light-colored, nonphosphatic chert is known in the region. The thickness of the Silurian strata is unknown because neither the top nor the base is exposed and because of complex internal faulting.

OVERLAP ASSEMBLAGE

Conventionally, upper Paleozoic sequences that nonconformably overlie the Roberts Mountains allochthon collectively are called the overlap assemblage. The overlap assemblage can range in age from Early Mississippian to Permian, but commonly, as in the Dorsey Canyon–Mount Ichabod area, it ranges from Late Pennsylvanian into Permian.

In both the Mount Ichabod and Dorsey Canyon areas (figs. 2, 4), strata of the Roberts Mountains allochthon are overlain unconformably by an Upper Pennsylvanian and Permian sequence that consists, from base to top, of conglomerate, limestone, sandstone and siltstone, and bedded chert. In both areas, however, the rocks are disrupted by low- and high-angle faults, and the original succession must be pieced together from fragments. On Mount Ichabod, the unconformity, basal conglomerate, and limestone are well exposed, but the siltstone and sandstone strata are poorly represented and the chert unit is missing; near Mason Creek, the limestone and chert units are missing and the conglomerate is superposed tectonically on the siltstone-sandstone unit. At Dorsey Canyon, the unconformity is exposed and the conglomerate, siltstone and



EXPLANATION

QTu — **Volcanic and sedimentary rocks, undivided (Quaternary and Tertiary)**—Jarbidge Rhyolite, and unnamed lava flows, tuff, ignimbrite, alluvium, colluvium, lake deposits

PPPo — **Overlap assemblage (Permian and Upper Pennsylvanian)**—Complete sequence consists, in order, of basal conglomerate, limestone, sandstone and siltstone, and phosphatic bedded chert

SOu — **Unnamed strata (Silurian) and Valmy Formation (Ordovician) undivided**—Micaceous, feldspathic siltstone of Middle(?) Silurian age, bedded chert of Early(?) Silurian age; quartzite, bedded chert, shale, and argillite of Ordovician age

Contact

Section corner

U / D **High-angle fault**—U, upthrown side; D, downthrown side; dotted where concealed

25 **Strike of beds showing degree of dip**

61107 • **Fossil locality**—Number refers to table 1

Figure 4. Geology of Dorsey Canyon area. The Roberts Mountains allochthon is overlain unconformably by strata of the overlap assemblage displaying, in the western exposure, the basal unconformity and, in the eastern exposure, the gradational contact between the siltstone and sandstone unit and the overlying bedded chert unit.

sandstone, and chert units are well represented, but the limestone unit is absent. Clasts in the conglomerate are composed of quartzite and chert, both evidently derived from components of the underlying Roberts Mountains allochthon. The siltstone and sandstone unit is composed mainly of quartz and chert grains.

In the northwestern corner of the Mount Ichabod map area (fig. 2) is a small outcrop of heterogeneous conglomerate (unit Pc) whose contact with underlying units is not exposed. It is unique in its lithic composition and totally unlike any other stratigraphic unit in the Bruneau River region. Principal components are boulder conglomerate, sandstone, siltstone, and bedded chert. Boulders were derived from phosphatic Permian rocks, from the Pennsylvanian part of the overlap assemblage, and from the Valmy Formation. The bedded chert yielded radiolarians whose age range is Pennsylvanian to Permian (Wolfcampian), but the presence of boulders rich in phosphate suggests that the formation is younger than Wolfcampian. Richly phosphatic strata in the region are commonly of Leonardian or Guadalupian age. The unit does not resemble any known Triassic rocks. We interpret the paleontological and lithic data to indicate a Permian, rather than Triassic, age for the unit, and we regard the unit as an allochthonous facies of the overlap assemblage.

In spite of the lack of an exposed limestone unit at Dorsey Canyon, the overlap assemblage is more complete there than elsewhere in the Mount Ichabod–Dorsey Canyon area. Moreover, both the depositional basal contact and the gradational transition from the siltstone and sandstone unit to the chert unit are exposed. The exposure of a gradational transition from siltstone and sandstone to overlying chert is important because it solves a stratigraphic problem of long standing. Coats and Gordon (1972) discussed two stratigraphic units in the Dorsey Canyon area: a siltstone and sandstone unit termed the Edna Mountain Formation that they believed was allochthonous, and a chert unit termed the Phosphoria Formation that they believed was autochthonous. Actually, these units are in stratigraphic continuity and constitute the upper two stratigraphic divisions of the overlap assemblage near Dorsey Canyon.

The overlap assemblage in the Mount Ichabod–Dorsey Canyon area is Late Pennsylvanian and Permian in age. Fusulinids from limestone on Mount Ichabod are Late Pennsylvanian (R.C. Douglass, oral commun., 1988), and brachiopods and molluscs from the siltstone-sandstone unit are Permian (Coats and Gordon, 1972; Coats, 1986).

The presence of abundant meandering trace fossils on bedding surfaces of the siltstone-sandstone unit could indicate a depositional environment of relatively deep water, but some strata of this unit also contain a sporadic macrofauna of large whole brachiopods and molluscs in a silty or sandy matrix that indicates a well-oxygenated and probably relatively shallow water environment. However the paleontological evidence is interpreted, the overlap assemblage includes basal conglomerate composed of large clasts identical in composition to unconformably underlying strata that indicates an environment above wave base. This sequence is in contrast to the Havallah sequence in which beds approximately contemporaneous with the basal conglomerate of the overlap assemblage consist of bedded chert and fine-grained detrital rocks that commonly are indicative of a deeper water environment.

The overlap assemblage is estimated to be several hundred feet thick in the study area, but an accurate measurement is impossible because of the presence of low- and high-angle faults.

GOLCONDA ALLOCHTHON

In this report, the tectonic term "Golconda allochthon" is used to describe a tract of rootless, complexly deformed, siliceous, dominantly deep water, sedimentary rocks of late Paleozoic (Mississippian to Permian) age. Upper Devonian strata in the allochthon elsewhere in northern Nevada have been reported (Miller and others, 1984). Volcanic rocks are not important constituents of the allochthon in the Mount Ichabod area as they are elsewhere. "Havallah sequence" is a stratigraphic term used to describe the principal component of the allochthon; however, slices of the overlap assemblage in low-angle fault contact within or above the Havallah also can be regarded as part of the allochthon. Parts of the Havallah and the overlap assemblage are lithically identical, and in some places it is impossible to determine whether isolated outcrops should be assigned to the Havallah or to the overlap assemblage.

HAVALLAH SEQUENCE

In the vicinity of Mount Ichabod, the Havallah sequence is composed mainly of yellow-weathering siltstone and fine-grained sandstone, but dark-gray to black bedded chert and argillite are important constituents. Only a few very thin lenses of limestone were observed in the vicinity of Mount Ichabod, although most of the siliceous detrital beds are somewhat calcareous. In contrast, thick limestone turbidites and debris flows are prominent constituents in more northerly outcrops of the Havallah sequence. Typically the siltstone and fine-grained sandstone are composed mainly of angular clasts of quartz and lesser proportions of detrital calcite and dolomite rhombs. Detrital chert, microcline, plagioclase, muscovite, siliceous spicules, and phosphate are sporadically present in small amounts.

Many beds classed as chert in outcrop are actually detrital rocks as seen in thin sections, consisting almost entirely of siliceous spicules of mainly fine sand size. Minor constituents of these rocks are quartz sand, dolomite rhombs, clastic calcite, clastic phosphate, and

Table 1. Age range of fossil collections in and near the Mount Ichabod and Dorsey Canyon map areas, Elko County, Nevada.

[C, conodont; R, radiolarian; B, brachiopod; M, mollusc; F, fusulinid; G, gastropod, see acknowledgments for discussion of specialists]

Sample number	Kind of fossil	Age range of collection	Specialist
		VALMY FORMATION, DORSEY CANYON VICINITY (FIG. 1)	
70139	C	Middle Ordovician	Huddle
		OVERLAP ASSEMBLAGE, MOUNT ICHABOD (FIG. 2)	
12722	F	Late Pennsylvanian	Douglass
12771	C	Early Middle Pennsylvanian (in clast)	Wardlaw
12770	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
12931	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
71076	C	Pennsylvanian to Permian	Huddle
		OVERLAP ASSEMBLAGE, DORSEY CANYON (FIG. 4)	
13551	BM	Permian	Gordon
61107	BM	Permian	Gordon
62013	BM	Permian	Gordon
62037	BM	Permian	Gordon
62038	BM	Permian	Gordon
62302	BM	Permian	Gordon
		HAVALLAH SEQUENCE, MOUNT ICHABOD MAP AREA (FIG. 2)	
12715	C	Early Pennsylvanian	Sandberg
12716	R	Middle Pennsylvanian	Murchey
12717	C	Late Middle or Early Pennsylvanian	Sandberg
12718	R	Middle Pennsylvanian	Murchey
12739	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
12750	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
12751	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
12752	R	Permian (Leonardian)	Murchey
12760	R	Permian (Leonardian)	Murchey
12762	C	Mississippian (Chesterian)	Wardlaw
12764	C	Mississippian	Wardlaw
12805	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
12810	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
12918	R	Early Permian (probably Leonardian	Murchey
12924	R	Middle Pennsylvanian	Murchey
12991	R	Pennsylvanian to Permian (Wolfcampian)	Murchey
		DOLLY CREEK SEQUENCE, MOUNT ICHABOD (FIG. 2)	
12723	C	Latest Permian (presumably in clasts)	Sandberg
12755	C	Earliest Triassic (Griesbachian)	Wardlaw
12756	C	Early Middle Pennsylvanian (in clast)	Wardlaw

phosphatic pellets. Such beds are commonly of Permian age. Chert beds without detrital components and characterized by scattered radiolaria are possibly of hydrothermal origin (Ketner, 1991) and are more commonly of Mississippian or Pennsylvanian age.

The limestone lenses, very thin and sparse in the Mount Ichabod area, consist, in part, of brachiopod, pelecypod, and crinoidal debris. Other exposures of Havallah limestone in the Bruneau River region are extensive debris flows consisting of bioclastic debris and a significant proportion of radiolarian-bearing chert clasts, apparently derived ultimately from the Roberts Mountains allochthon. The source of the detrital carbonate component could have been the shelf area bordering the western margin of the Antler orogen, as suggested by Sando (1992).

The age range of the Havallah sequence in the vicinity of Mount Ichabod, based on numerous collections of conodonts and radiolarians, is late Early Mississippian to mid-Permian. The stratigraphic thickness of the sequence is impossible to determine because of structural complexity and poor exposures.

DOLLY CREEK SEQUENCE

The Dolly Creek sequence is composed of two distinct facies of detrital rocks: a relatively fine grained facies derived from a distant source to the east and a relatively coarse grained debris-flow facies apparently derived from nearby exposures of the Valmy Formation and the

Table 1. Age range of fossil collections in and near the Mount Ichabod and Dorsey Canyon map areas, Elko County, Nevada—Continued.

Sample number	Kind of fossil	Age range of collection	Specialist
		HAVALLAH SEQUENCE, NEAR THE MOUNT ICHABOD MAP AREA (FIG. 1)	
12953	R	Pennsylvanian to Permain (Wolfcampian)	Murchey
12968	R	Early Permian (Leonardian)	Murchey
12972	R	Mississippian (probably Late)	Murchey
13011	C	Late Mississippian (late Chesterian)	Stamm
13014	C	Latest Meramecian to early late Chesterian	Stamm
13015	C	Mississippian (early late Chesterian)	Stamm
13016	C	Pennsylvanian (Atokan)	Stamm
13027	C	Late Mississippian (early late Chesterian)	Stamm
13028	C	Mississippian (late Osagean to Chesterian)	Stamm
58056	C	Late Mississippian.	Hass
60009	F	Middle Pennsylvanian (Desmoinesian)	Douglass
60010	F	Middle Pennsylvanian	Douglass
60011	C	Middle Pennsylvanian to Permian	Huddle
61029	G	Latest Pennsylvanian to Permian	Yochelson
62301	C	Late Mississippian	Huddle
69113	C	Early Pennsylvanian	Huddle
69114	C	Early Pennsylvanian	Huddle
69117	C	Late Mississippian	Huddle
69118	C	Late Mississippian	Huddle
69119	C	Late Mississippian	Huddle
71004	C	Early Pennsylvanian	Huddle
71011	B	Mississippian	Gordon
71013	B	Mississippian.	Gordon
71015	C	Pennsylvanian to Permian	Huddle
71021	C	Late Mississippian to Early Pennsylvanian(?)	Huddle
71022	C	Late Mississippian	Huddle
71024	C	Late Mississippian	Huddle
71027	C	Pennsylvanian to Permian	Huddle
71070	C	Early Pennsylvanian	Huddle
71097	C	Late Mississippian	Huddle
72035	C	Early Pennsylvanian	Huddle
72037	C	Early Pennsylvanian	Huddle
72040	C	Early Pennsylvanian	Huddle
72043	C	Early Pennsylvanian	Huddle
72063	F	Late Pennsylvanian	Douglass
72064	C	Early Pennsylvanian	Wardlaw
72150	C	Early Pennsylvanian to Permian	Huddle
72151	C	Late Mississippian	Huddle

overlap assemblage to the west. The coarse-grained facies merges laterally with strata of the fine-grained facies in the Mount Ichabod area, and alternating beds of the two facies are exposed in an area of 0.04 mi^2 (0.1 km^2) in one of the tributaries of Dolly Creek. The easterly derived fine-grained facies is also exposed in the Adobe Range 30 mi (48 km) to the south (Ketner and Ross, 1990), but there easterly derived coarse debris flows are present in the fine-grained facies and westerly derived debris is absent.

The fine-grained facies is composed primarily of limy siltstone and silty limestone. Limy sandstone is a minor constituent. The facies displays thin lamination, graded bedding, and, rarely, sole marks. Most of the clasts that are coarse enough to be identifiable are composed of debris of brachiopods, corals, pelmatozoans, and other shelly organisms. Many clasts are composed of spiculitic, phosphatic chert, phosphorite, and fine-grained quartz sandstone. Most of the clasts observed in the field and in thin section suggest a shallow-water provenance terrane. Reworked Permian conodonts and the spiculitic and phosphatic clasts suggest that the provenance terrane was at least partly of Permian age. In the Adobe Range, debris flows in the fine-grained turbidite facies include fossiliferous boulders, whose lithic features and fauna clearly indicate that they were derived from the Gerster Formation.

The Gerster is a Permian shallow-water shelf deposit of the Nevada-Utah border area.

The coarse debris-flow facies near Mount Ichabod is composed of structureless masses and eastward-thinning beds of conglomerate. The structureless masses include very large clasts of Valmy quartzite, one of which is at least 10 ft (3 m) in diameter. One large limestone clast contains, in addition to a shelly macrofauna, conodonts of Middle Pennsylvanian age. Its size, age, and lithic composition indicate that it was derived from the local overlap assemblage.

Conodonts collected from the fine-grained turbidite facies where it is interlayered with the debris-flow facies indicate an earliest Early Triassic (Griesbachian) age for both the conglomerate and the lower beds in the fine-grained turbidite sequence. Because the Triassic rocks are detrital, it is possible that the conodonts were reworked. Ammonites from the same formation exposed in the Adobe Range indicate a middle Early Triassic age, and conodonts from large clasts in a similar unit in the northern Snake Mountains, 30 mi (48 km) to the east of Mount Ichabod, indicate a latest Early Triassic age. The age range of the Dolly Creek sequence in the Mount Ichabod area therefore could span the entire Early Triassic.

The depositional base and top of the Dolly Creek sequence are not exposed, but the formation must be at least 6,000 ft (1,829 m) thick, assuming there is no repetition of beds along concealed faults. It is unlikely that the exposed part of the unit is isoclinally folded because only one small fold nose and no large ones were observed. Moreover, the distinctive conglomerate facies is not repeated. The homoclinal dip of the sequence, however, suggests that the exposed part could be the limb of a very large fold.

TERTIARY AND QUATERNARY DEPOSITS

Paleogene ignimbrite, alluvium, and lake deposits are widely exposed in the region and these commonly dip about 25° to the northwest as a result of rotation on extensional faults. Locally, 4–5 mi (6–8 km) northwest of Mount Ichabod, Paleogene alluvium has been tilted about 65° to the west. Neogene rocks include the ubiquitous middle Miocene Jarbidge Rhyolite, slightly older and younger volcanic strata, and alluvium and lake deposits. The Neogene deposits have been only slightly tilted by basin and range faulting. Quaternary deposits include alluvium along streams, colluvium, and landslides.

PRINCIPAL STRUCTURAL FEATURES

The Mount Ichabod area displays two principal structural styles: low-angle contractional faulting and high-angle extensional faulting.

POST-EARLY TRIASSIC CONTRACTION

The emplacement of the Roberts Mountains and Golconda allochthons on Triassic rocks is the most visible display of low-angle, older-over-younger, contractional faulting in the area, but the presence of Ordovician rocks in the Mount Ichabod horst shows that parts of the Roberts Mountains allochthon and of the overlap assemblage *underlie* as well as *overlie* the Triassic sequence (fig. 3). The imbrication resulted in thickening of the stratigraphic section, a certain indicator of contraction.

Two partly contemporaneous facies of upper Paleozoic sequences, originally more widely separated, were telescoped together and imbricated in the Mount Ichabod area by low-angle faulting: the relatively fine grained, more outboard Havallah sequence and the relatively coarse grained, more inboard overlap assemblage. This, too, represents contractional faulting. Extensional faulting would have moved the contemporaneous facies farther apart than they were originally.

Strong, large-scale folding is not clearly displayed in the Mount Ichabod–Dorsey Canyon area. Restoration of the prevalent northwest dip of the older Tertiary strata to horizontal, however, increases the amount of dip of the Triassic strata to 60° or more to the east, suggesting that the Triassic strata had been strongly folded on a very large scale, another indication of contractional strain.

PALEOGENE EXTENSION

Evidence from the northern part of the study area, 10–20 mi (16–32 km) north of Mount Ichabod (fig. 1), suggests that early Tertiary extension was an important tectonic event in at least part of the Bruneau River region. There, metamorphosed Proterozoic and Cambrian quartzite intruded by large coarse-grained monzonitic stocks of Cretaceous age crop out extensively. The very coarse grained borders of these stocks indicate that the stocks cooled at great depth. Proterozoic and Cambrian strata, the oldest rocks exposed in the area, now are exposed at some of the highest elevations in the region. Moreover, Paleogene sedimentary and volcanic rocks have been rotated from the horizontal and dip toward their fault contact with the Proterozoic rocks at an angle of about 25°. These relations are typical of highly extended terranes and are interpreted to imply the presence of early Tertiary extensional low-angle faults in the northern half of the Bruneau River region, but no such faults have been certainly identified in the Mount Ichabod–Dorsey Canyon area.

NEOGENE EXTENSION

Late Tertiary high-angle extensional faults are definitely present in the Mount Ichabod–Dorsey Canyon area.

Among the most prominent are those flanking Mount Ichabod and Mason Mountain on the west. These are partly exposed, steeply west dipping, normal faults that cut the middle Miocene Jarbidge Rhyolite. Mount Ichabod is also bounded on the east by a high-angle, east-dipping normal fault. The bounding normal faults define Mount Ichabod as a horst that reveals the kind of strata underlying, and concealed by, the stratigraphic and structural units exposed in the adjacent grabens.

DISCUSSION

The Roberts Mountains allochthon is imbricated with the Dolly Creek sequence and therefore was emplaced after Early Triassic time, confirming the age of emplacement demonstrated earlier from evidence in the Adobe Range (Ketner and Ross, 1990). The Golconda allochthon, identified by its lithic composition and an abundance of paleontological data, is present in the Mount Ichabod area and by its structural position above the Dolly Creek sequence is proved to have been emplaced after Early Triassic time. The superposition of the allochthon on Lower Triassic rocks constitutes the most unambiguous evidence pertaining to the age of the Golconda thrust fault that exists anywhere. Although the surface on which both the Roberts Mountains allochthon (in part) and the Golconda allochthon lie is curved owing to original form or folding (fig. 2), the lack of a distinct break in the pattern of structure contours indicates that the allochthons probably lie on essentially the same fault surface. It would be an unlikely coincidence if they had happened to arrive at the same structural horizon at different times, and therefore we conclude that they probably were emplaced simultaneously. The most likely time of emplacement was during the Elko orogeny in Middle to Late Jurassic time (Thorman and others, 1991), but earlier or later times between the Middle Triassic and the Tertiary cannot be ruled out (Ketner and Alpha, 1992).

The question of whether emplacement of the Roberts Mountains allochthon in the Mount Ichabod–Dorsey Canyon area might represent reactivation of a middle Paleozoic Antler-age fault is answered in the negative by stratigraphic evidence from three areas: the northern part of the Bruneau River region (Ketner and others, 1993a, b), the Mountain City area adjacent to it on the west (Coats, 1971; unpublished data), and the East Range of northwestern Nevada (Whitebread, 1978; unpublished data). In all three areas Lower Mississippian strata of the overlap assemblage lie *disconformably* on the quartzite member of the Valmy Formation. There is no structural evidence in these areas of strong folding or faulting between Ordovician and Mississippian time, but, rather, the evidence suggests widespread uplift of rocks now comprising the Roberts Mountains allochthon and rapid erosion of Devonian, Silurian, and Upper Ordovician strata down to a uniform stratigraphic level, the Middle Ordovician. The emplacement of the Roberts Mountains allochthon at Mount Ichabod should not, therefore, be interpreted as reactivation of a hypothetical middle Paleozoic thrust fault. Evidence for middle Paleozoic folding or low-angle faulting has not been discovered in the Bruneau River region.

REFERENCES CITED

Bushnell, K.O., 1967, Geology of the Rowland quadrangle, Elko County, Nevada: Nevada Bureau of Mines Bulletin 67, 38 p.

Coash, J.R., 1967, Geology of the Mount Velma quadrangle, Elko County, Nevada: Nevada Bureau of Mines Bulletin 68, 21 p.

Coats, R.R., 1971, Geologic map of the Owyhee quadrangle, Nevada-Idaho: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–665, scale 1:48,000.

——— 1986, Invertebrate and paleobotanical fossils collected in Elko County, Nevada: Nevada Bureau of Mines and Geology Open-File Report 86–1, 397 p.

——— 1987, Geology of Elko County, Nevada: Nevada Bureau of Mines and Geology Bulletin 101, 112 p.

Coats, R.R., and Gordon, Mackenzie, Jr., 1972, Tectonic implications of the presence of the Edna Mountain Formation in northern Elko County, Nevada: U.S. Geological Survey Professional Paper 800–C, p. C85–C94.

Johnson, J.G., and Pendergast, Anne, 1981, Timing and mode of emplacement of the Roberts Mountains allochthon, Antler orogeny: Geological Society of America Bulletin, v. 92, p. 648–658.

Ketner, K.B., 1991, Stratigraphy, sedimentology, and depositional conditions of lower Paleozoic western-facies rocks in northeastern Nevada, *in* Cooper, J.D., and Stevens, C.H., eds., 1991, Paleozoic paleogeography of the western United States–II: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 67, p. 735–746.

———1992, Preliminary geologic map of the Mount Ichabod area, Elko County, Nevada: U.S. Geological Survey Open-File Report 92–580, scale 1:24,000.

Ketner, K.B., and Alpha, A.G., 1992, Mesozoic and Tertiary rocks near Elko, Nevada—Evidence for Jurassic to Eocene folding and low-angle faulting: U.S. Geological Survey Bulletin 1988–C, 13 p.

Ketner, K.B., Ehman, K.D., Repetski, J.E., Stamm, R.G., and Wardlaw, B.R., 1993a, Paleozoic stratigraphy and tectonics in northernmost Nevada—Implications for the nature of the Antler orogeny: Geological Society of America Abstracts with Programs, v. 25, no. 5.

Ketner, K.B., Repetski, J.E., Wardlaw, B.R., and Stamm, R.G., 1993b, Preliminary geological map of the Rowland-Bearpaw Mountain area, Elko County, Nevada: U.S. Geological Survey Open-File Report 93–220, scale 1:24,000.

Ketner, K.B., and Ross, R.J., Jr., 1990, Geologic map of the northern Adobe Range, Elko County, Nevada: U.S. Geological Survey Miscellaneous Investigations Map I–2081, scale 1:24,000.

Little, T.A., 1987, Stratigraphy and structure of metamorphosed upper Paleozoic rocks near Mountain City, Nevada: Geological Society of America Bulletin, v. 98, p. 1–17.

Miller, E.L., Holdsworth, B.K., Whiteford, W.B., and Rodgers, D., 1984, Stratigraphy and structure of the Schoonover sequence, northeastern Nevada—Implications for Paleozoic plate-margin tectonics: Geological Society of America Bulletin, v. 95, p. 1063–1076.

Roberts, R.J., Hotz, P.E., Gilluly, James, and Ferguson, H.G., 1958, Paleozoic rocks of north-central Nevada: American Association of Petroleum Geologists Bulletin, v. 42, p. 2813–2857.

Sando, W.J., 1992, Paleogeographic significance of Mississippian coral localities in Antler orogen, central Nevada: Geological Society of Nevada, Rocky Mountain Section, Abstracts with Programs, v. 24, no. 6, p. 60.

Schwarz, D.L., Snyder, W.S., and Hutter, T.J., 1991, Tectonostratigraphy of the Ordovician Tennessee Mountain Formation, Permian Sunflower Formation, and the Poorman Peak sequence, Wild Horse area, north-central Elko County, Nevada, *in* Cooper, J.D., and Stevens, C.H., eds., 1991, Paleozoic paleogeography of the western United States–II: Pacific Section, Society of Economic Paleontologists and Mineralogists, v. 67, p. 357–369.

Silberling N.J., and Roberts, R.J., 1962, Pre-Tertiary stratigraphy and structure of northwestern Nevada: Geological Society of Nevada Special Paper 72, 53 p.

Stewart, J.H., and Carlson, J.E., 1978, Geologic map of Nevada: U.S. Geological Survey, scale 1:500,000.

Thorman, C.H., Ketner, K.B., Brooks, W.E., Snee, L.W., and Zimmerman, R.A., 1991, Late Mesozoic–Cenozoic tectonics in northeastern Nevada, *in* Raines, G.L., Lisle, R.E., Schafer, R.W., and Wilkinson, W.H., eds., Geology and ore deposits of the Great Basin: Geological Society of Nevada Symposium, Proceedings, v. 1, p. 25–45.

Whitebread, D.H., 1978, Preliminary geologic map of the Dun Glen quadrangle, Pershing County, Nevada: U.S. Geological Survey Open File Report 78–407, scale 1:48,000.

Published in the Central Region, Denver, Colorado
Manuscript approved for publication January 28, 1993
Graphics prepared by Mari L. Kauffmann and George Garcia
Type composed by Shelly A. Fields
Edited by Judith Stoeser

☆U.S. GOVERNMENT PRINTING OFFICE: 1993-774-049/66049

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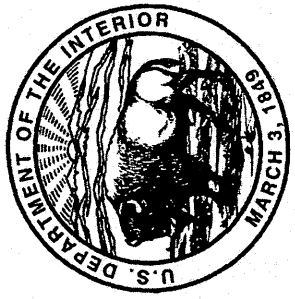
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