

# Some contrasting biostratigraphic links between the Baker and Olds Ferry Terranes, eastern Oregon

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**ABSTRACT:** New stratigraphic and paleontologic data indicate that ophiolitic *mélange* windows in the Olds Ferry terrane of eastern Oregon contain limestone blocks and chert that are somewhat different in age than those present in the adjacent Baker terrane *mélange*. The *mélange* windows in the Olds Ferry terrane occur as inliers in the flyschoid Early and Middle Jurassic age Weatherby Formation, which depositionally overlies the contact between the *mélange*-rich Devonian to Upper Triassic rocks of the Baker terrane on the north, and Upper Triassic and Early Jurassic volcanic arc rocks of the Huntington Formation on the south. The Baker terrane and Huntington Formation represent fragments of a subduction complex and related volcanic island arc, whereas the Weatherby Formation consists of forearc basin sedimentary deposits. The tectonic blocks in the *mélange* windows of the Weatherby Formation (in the Olds Ferry terrane) are dated by scarce biostratigraphic evidence as Upper Pennsylvanian to Lower Permian and Upper Triassic. In contrast, tectonic blocks of limestone in the Baker terrane yield mostly fusulinids and small foraminifers of Middle Pennsylvanian Moscovian age at one locality. Middle Permian (Guadalupian) Tethyan fusulinids and smaller foraminifers (neoschwagerinids and other Middle Permian genera) are present at a few other localities. Late Triassic conodonts and bryozoans are also present in a few of the Baker terrane tectonic blocks. These limestone blocks are generally embedded in Permian and Triassic radiolarian bearing chert or argillite. Based on conodont, radiolarian and fusulinid data, the age limits of the *mélange* blocks in the Weatherby Formation range from Pennsylvanian to Late Triassic.

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## INTRODUCTION

The largely ignored *mélange* inliers in the Weatherby Formation in the Olds Ferry terrane provide important clues to deciphering the tectonic evolution of the Blue Mountains province of northeastern Oregon and western Idaho. New data presented herein provide evidence for a loose connection between the Baker terrane *mélange* and the *mélange* inliers in the Weatherby Formation that clarifies how the Baker and Olds Ferry terranes developed.

Terrane names shown in text-figure 1 were introduced by Silberling et al. (1987), who formally named tectonostratigraphic units described by Brooks et al. (1976), Vallier et al. (1977), Brooks and Vallier (1978) and Dickinson and Thayer (1978). The Blue Mountains terranes are now considered to be tectonically telescoped and juxtaposed pieces of a complex island arc system (Vallier and Brooks 1986) that are a protracted record of arc-arc and terrane-continent collision that lasted from Late Triassic to Late Jurassic time (Dorsey and LaMaskin 2007, 2008). An updated figure modified from LaMaskin (2011b) is presented herein as text-figure 2 on which are also shown the few localities from which Tethyan and McCloud related fusulinid faunas have been found.

Early workers (Dickinson 1979; Brooks 1979a; White et al. 1992; Vallier 1995) interpreted Jurassic sequences in the Weatherby Formation to be part of a single fore-arc basin that extended beneath areas of Tertiary cover from western Idaho to the Izee area of central Oregon. Silberling et al. (1984) later divided the sequence into two separate terranes, combining the Weatherby and underlying formations into the Olds Ferry terrane (WOF in text-fig. 1) and placing similarly-aged Mesozoic rocks to the west into the Izee terrane (IZ in text-fig. 1).

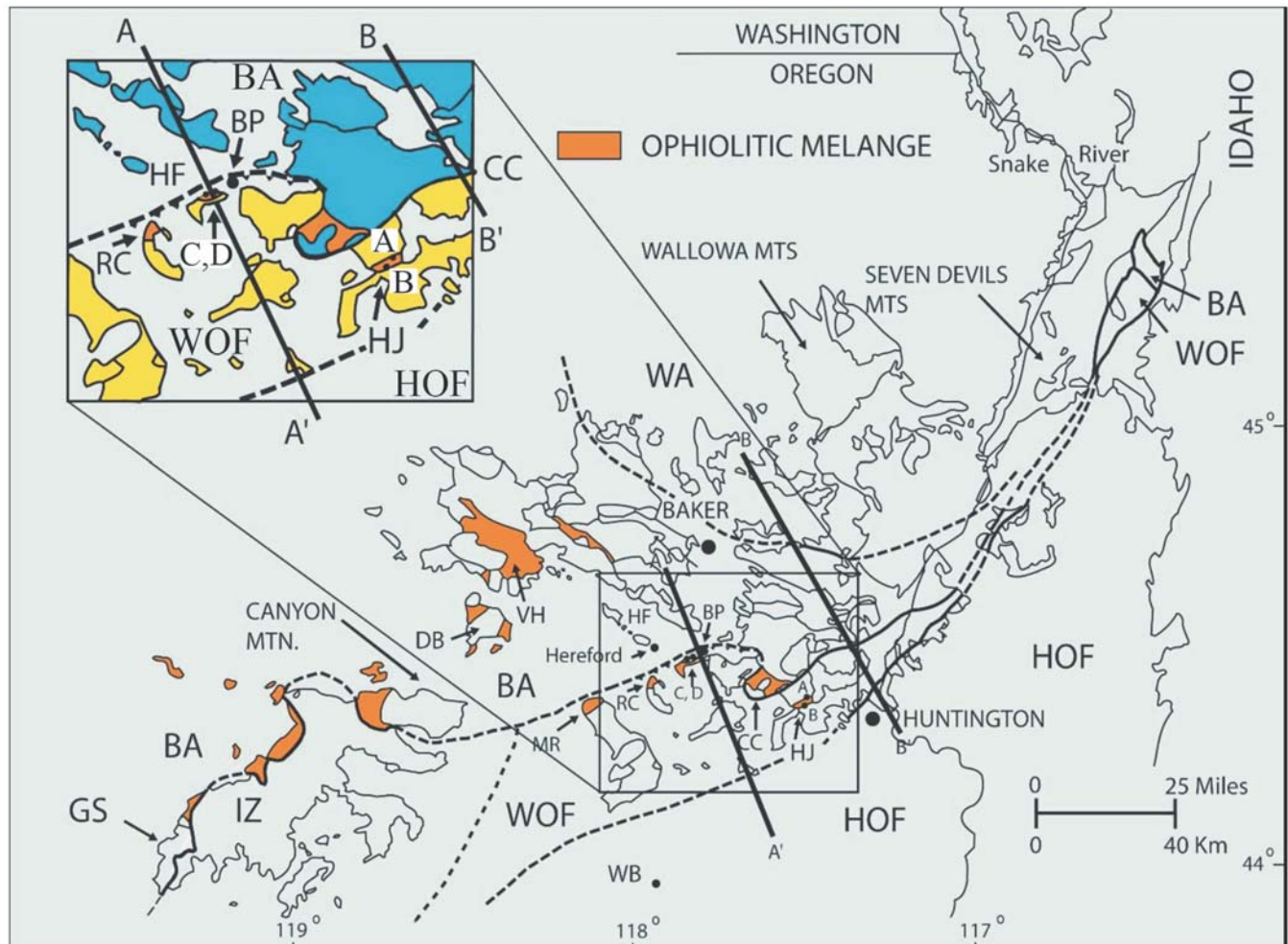
Brooks and Vallier (1978) had earlier suggested that the western Mesozoic exposures were more fossiliferous and less deformed than the rocks of the Weatherby Formation. For illustrative purposes we follow Silberling et al. (1984) and exclude the Weatherby Formation from the Izee terrane because the Izee rock units: (1) exhibit broader age ranges and more varied sedimentary lithologies, (2) contain several distinct and traceable formations, (3) display lower grade (zeolite facies) metamorphism and less intense deformation and (4) contain more abundant and better preserved fossils (Brooks and Vallier 1978; Blome et al. 1986; Blome and Nestell 1992). Others workers, such as LaMaskin et al. (2011a), consider the stratigraphic successions in both the Izee and Olds Ferry terranes to be parts of two linked megasequences.

Our fieldwork in northeastern Oregon along the boundary and in the Baker and Olds Ferry terranes allows us to present new data documenting the previously reported (Blome and Nestell 2007) biostratigraphic ages of some limestone pods in the eastern part of the Bourne terrane in the northern part of the Virtue Hills and also the biostratigraphic significance of a few ophiolitic *mélange* inliers in the Weatherby Formation.

## REGIONAL GEOLOGY

### BAKER TERRANE

The Baker terrane is a subduction-accretionary wedge-forearc tectonic complex consisting of disrupted fragments of oceanic floor and island-arc crustal rocks ranging in age from Middle Devonian to Early Jurassic (Nestell 1983; Walker 1986, 1995; Blome and Nestell 1991; Ferns and Brooks 1995; Nestell et al. 1995; Nestell and Nestell 1998; Nestell and Orchard 2000; Schwartz et al. 2010, 2011; Zak et al. 2012). The Baker terrane



TEXT-FIGURE 1

Distribution of pre-Tertiary rocks and generalized boundaries for terranes in the Blue Mountains of northeastern Oregon and western Idaho. BA, Baker terrane; BP, Bridgeport; CC, Connor Creek fault; DB, Dixie Butte; GS, Grindstone subterrane; HF, Hereford; HJ, Huntington Junction; HOF, Huntington Formation (Olds Ferry terrane); IZ, Izee terrane; MR, Mine Ridge; RC, Rock Creek Butte; VH, Vinegar Hill; WA, Wallowa terrane; WB, Westfall Butte; and WOF = Weatherby Formation (Olds Ferry terrane). Inliers of ophiolitic melange shown as shaded areas. Inlier fossil localities: A, Permian radiolarians; B, Late Triassic radiolarians; C, Pennsylvanian conodonts; and D, Pennsylvanian and Early Permian fusulinaceans. Modified from Brooks and Vallier (1978); Dickinson and Thayer (1978); terrane names modified from Silberling et al. (1987) and Ferns and Brooks (1995). In the insert are shown schematic sections across the southeastern part of the Blue Mountains. Cross section A-A' includes westward projection of a window of the Baker terrane surrounded by strata of the Weatherby Formation at Huntington Junction (HJ).

is equivalent to the central mélangé terrane of Dickinson (1979) and was originally defined as an oceanic terrane by Vallier et al. (1977). It is also said to be made up of dismembered oceanic crust (Brooks and Vallier 1978), and Paleozoic and Mesozoic mélangé (Dickinson and Thayer 1978; Blome and Nestell 1991; Ferns and Brooks 1995). Disrupted strata of the Baker terrane are believed to represent an accretionary mélangé situated outboard of the adjacent Mesozoic clastic terranes (IZ and WOF in text-fig. 1)

Kays et al. (1987) recognized three distinct subterrane in the Baker terrane: 1) one subterrane on the north, the dismembered Permian–Early Jurassic Elkhorn Ridge Argillite dominated Bourne subterrane (Ferns and Brooks 1995; Schwartz 2006); one subterrane on the southwest, the serpentinite-matrix mélangé-dominated Greenhorn subterrane and (3) along the

Connor Creek Fault to the east, the more coherent Burnt River Schist. LaMaskin et al. (2009) restored the concept of the Baker terrane to the original extent of the oceanic crust terrane of Brooks (1979b) by redefining the Grindstone terrane of Silberling et al. (1984) as a subterrane of the Baker terrane. Thus, following modern terminology, three subterrane of the Baker terrane are recognized herein: the Bourne, the Greenhorn, and the Grindstone subterrane. The lithofacies of limestone blocks of the Grindstone subterrane are essentially unmetamorphosed and distinctly different from the lithofacies of those limestone blocks in the Greenhorn and Bourne subterrane which exhibit extensive metamorphism. Thus, the inclusion of the Grindstone subterrane in the Baker terrane is suspect.

Chert and enclosed limestone blocks in the northern part of the Bourne subterrane are mostly of middle Permian (Guadalupian)

and Late Triassic (early Carnian to late Norian) ages (Blome et al. 1986; Pessagno and Blome 1986; Nestell and Blome 1988; Blome and Nestell 1992). Limestone blocks containing Devonian conodonts (Morris and Wardlaw 1986) and Middle Pennsylvanian fusulinids (Brooks et al. 1976; Nestell and Orchard 2000) and Early and Middle Permian fusulinids (Bostwick and Koch 1962) are also reported from Bourne subterranean units.

Fault-bounded slabs of Middle and Late Triassic arc-related volcanoclastic and sedimentary rocks crop out in the northern part of the Bourne subterranean, near the concealed boundary between the Wallowa and Baker terranes (Ferns and Brooks 1995; Schwartz et al. 2010, 2011). These slabs are considered by Ferns and Brooks (1995) and Schwartz et al. (2010, 2011) to be tectonic fragments from the Wallowa terrane that were emplaced in the Jurassic along low-angle faults.

Fossil data from the Greenhorn subterranean provide some time constraints on mélange formation and suggest multiple events in its development. Bedded Permian strata in the Vinegar Hill area (VH in text-fig. 1) depositionally overlie ophiolitic mélange (Brooks et al. 1983). Nearby mélange blocks include ribbon chert of Late Triassic age. At Dixie Butte, ophiolitic mélange with chert blocks that contain early Late Permian (early Guadalupian) radiolarians (Blome in Brooks et al. 1984) are overlain by the Dixie Butte Meta-andesite (Brooks et al. 1984), a middle Jurassic metavolcanic complex (Schwartz et al. 2011).

#### OLDS FERRY TERRANE

The Olds Ferry terrane of Silberling et al. (1987) includes the Huntington Formation and overlying Weatherby Formation. The Huntington Formation is chiefly composed of Middle Triassic to Lower Jurassic, weakly metamorphosed, volcanic, volcanoclastic, and sedimentary rocks that were first referred to as the Juniper Mountain-Cuddy Mountain volcanic arc terrane (Brooks and Vallier 1978). The overlying Weatherby Formation includes Lower Jurassic sedimentary rocks that were first termed the flysch terrane (Brooks and Vallier 1978), and were later included with lithologically similar Triassic and Jurassic sedimentary deposits in the John Day inlier (IZ in text-fig. 1) as Dickinson's (1979) Mesozoic clastic terrane and Brooks' (1979b) fore-arc basin terrane.

The Huntington Formation (Brooks 1979a) of Middle Triassic to Early Jurassic age consists predominantly of mafic to silicic lava flows, and volcanic agglomerate and tuff of island-arc affinity. Volcanic rocks range in composition from basalt to rhyolite with andesite being the most abundant and record arc-related plutonism and volcanic activity from Middle Triassic to Early Jurassic time (Walker 1995; Tumpane and Schmitz 2009; Schwartz et al. 2011). Interbedded fine-grained sedimentary rocks form bedded sequences from a few meters to 100m thick and are of zeolite and greenschist metamorphic facies grade. The Huntington Formation unconformably underlies the Jet Creek Member of the Weatherby Formation. The Late Triassic (late Carnian and late middle Norian) age for part of the Huntington Formation is based on ammonites (LaMaskin 2008). Late Triassic coral and sponge-rich detritus have been found in thick-bedded cobble to boulder-conglomerate in the Huntington Formation (LaMaskin et al. 2011b) located at a considerable distance east of the mélange inliers reported herein. LaMaskin et al. (2011b) considered this fauna to be "Tethyan" related and likely locally reworked from an eroded reef within

the Huntington Formation. Although bedding features are obscured by a pervasive, steeply-dipping shear cleavage, the entire Huntington Formation may be as much as 6,000m thick (Brooks 1979a).

The overlying Weatherby Formation forms an east to northeast tapering belt that extends from the vicinity of Ironside Mountain in Oregon on the west to the Cuddy Mountain area of Idaho on the east (text-fig. 1). The Weatherby Formation (Brooks and Vallier 1978; Brooks 1979b; Dickinson 1979) is of Early (early Sinemurian) to Middle Jurassic (late Bajocian) age (Imlay 1986).

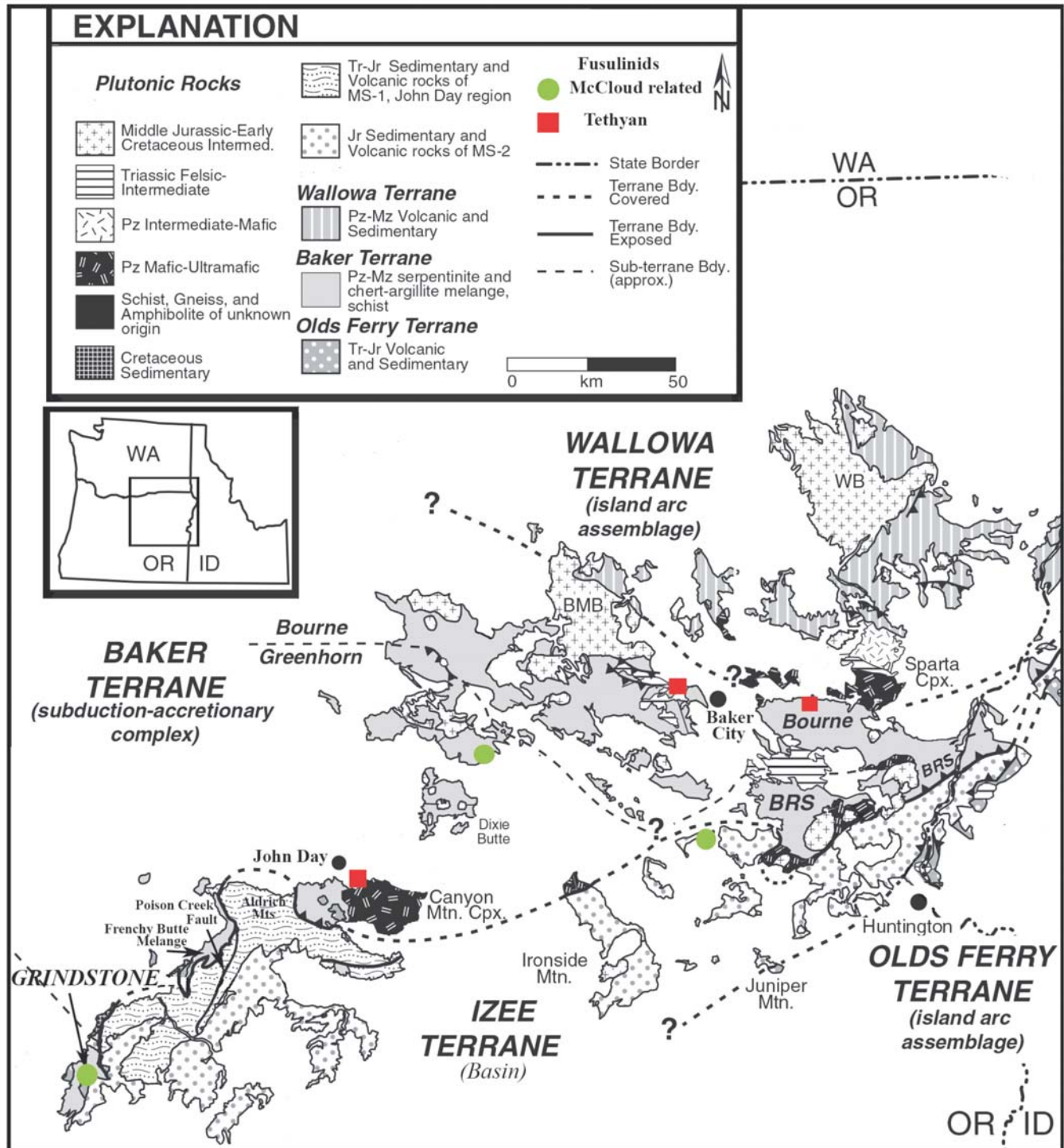
Mappable units in the lower part of the Weatherby Formation near the contact with the underlying Huntington Formation include the Jett Creek, Limestone Butte and Phipps Creek Members. Shallow-water deposits near the base of the Weatherby are composed of conglomerate, tuff, limestone, gypsum, and anhydrite.

The Weatherby Formation is bound on the northwest by the northeast-striking, steeply northwest-dipping Connor Creek fault (CC in text-fig. 1; Brooks and Vallier 1978; Schwartz et al. 2011), which emplaced Baker terrane Burnt River Schist ophiolitic mélange rocks over younger Jurassic Weatherby Formation rocks. Late Jurassic fold axes in Burnt River Schist north of the Connor Creek fault and Weatherby Formation south of the fault parallel the fault. Folds in both units are overturned to the south (Avé Lallemant 1983, 1995). Weatherby Formation sediments south of the Connor Creek fault are characterized by a pervasive penetrative axial-plane cleavage that strikes northeast and dips steeply to the southeast, obscuring bedding planes. Orientations of imbricate shear planes and small faults indicate that shearing resulted from southeast directed thrusting (Brooks et al. 1976; Brooks and Vallier 1978; Avé Lallemant 1983, 1995).

The principal contact between the Baker terrane and the Weatherby Formation varies: (1) from steeply dipping (northwest) along the Connor Creek fault (CC in text-fig. 1) in the eastern part of the region (Brooks et al. 1976), (2) to subhorizontal along the Burnt River southeast of Hereford and near vertical in the Rock Creek Butte area southeast of Hereford (HF in text-fig. 1), and (3) to vertical in the Mine Ridge area (MR in text-fig. 1; Brooks and Ferns 1979). Evans (1995) suggests a structural model in which the contact is folded and has undergone slip throughout its extent. The Weatherby basin may have closed as a result of southeast-directed (in present-day coordinates) folding in addition to shearing along the original unconformable basal contact of rocks of the Weatherby Formation and imbricate faulting within the formation. Part of the Weatherby Formation may have been overridden to account for the rapid eastward narrowing of its exposure belt. According to this model, the observable variations in the attitude of the main Baker terrane-Weatherby contact are a function of the depth of erosion of the major southeast-vergent fold. Exposures of the Baker terrane in the axial region of the overturned syncline (text-fig. 1a) could be flatter or steeper than the overturned limb exposures of the Baker terrane along the Connor Creek fault. Furthermore, the northeast-trending inliers of the Baker terrane within the Weatherby basin southeast of the Connor Creek fault could be parts of one or more subordinate anticlines that parallel the principal overturned syncline (text-fig. 3).

Coarse-grained volcanic clastic components near the base of the Weatherby Formation in the south are likely derived from the underlying, largely andesitic Huntington Formation (Brooks





TEXT-FIGURE 2

Generalized geologic map of the Blue Mountains Province (modified from LaMaskin 2011b). Question marks indicate uncertain terrane affiliations and/or terrane boundary locations. In recent literature, the Bourne and Greenhorn subterrane, Grindstone terrane, and Burnt River Schist are considered as subterrane-level units of the Baker terrane. Pz - Paleozoic; Mz - Mesozoic; Tr - Triassic; Jr - Jurassic; K - Cretaceous; M - megasequence (after Dorsey and LaMaskin, 2007); BRS—Burnt River Schist; BMB—Bald Mountain batholith; WB—Wallowa batholith; Cpx.- complex; WA - Washington; OR - Oregon; ID - Idaho. Areas with Tethyan related fusulinids denoted by a red rectangle refer to the Virtue Hills (this paper) to the southeast of Baker City, Elkhorn Mountains northwest of Baker City, and Dog Creek southeast of John Day; with McCloud related fusulinids denoted by a green circle refer to Vinegar Hill, southeast of Hereford (this paper), and various sites in the Grindstone subterrane. McCloud related refers to extensive fusulinid fauna described from the Lake Shasta area on northern California by various workers.

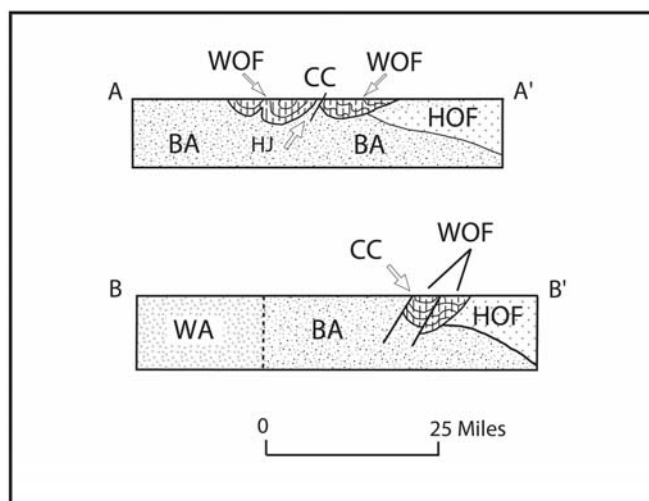
1979a). Basal conglomerate in the Jett Creek Member (Brooks and Baxter 1989) contains rounded volcanic cobbles and boulders. Intraformational conglomerate near the mélangé contains chert, serpentinite, and limestone clasts derived from mélangé blocks that are similar to lithologies in the Baker terrane to the north (Blome and Nestell 2007).

The clastic components of the Weatherby Formation are interpreted to have come from the largely andesitic Huntington Formation (Brooks 1979a). The basal, conglomeratic Jett Creek Member (Brooks and Baxter 1989) is as much as 250m thick and is mainly composed of red, purple, and green volcanic cobbles and boulders in a clastic matrix that rests unconformably on Upper Triassic volcanic and sedimentary rocks (Brooks 1979a; Imlay 1980). Fossils including ammonites, pelecypods, and corals occur in thin, calcareous graywacke associated with the mostly rounded, non-sheared conglomerate clasts and cobbles that are a peculiar dark green color (H. C. Brooks written communication 1974 in Imlay 1980, p. 64). An ammonite dated by Imlay as Pliensbachian in age (locality 1 in text-fig. 4) was also recovered from one of these graywacke interbeds (H. C. Brooks personal communication 1993).

The presence of intraformational conglomerate and large blocks of mixed Baker terrane rocks in these Weatherby inliers indicate that the floor and outer margin of the Weatherby basin was tectonically active during flysch deposition. The unit also contains conglomeratic zones rich in chert, serpentinite, and limestone clasts as well as isolated ophiolitic mélangé blocks that are similar to lithologies in the Baker terrane to the north (Blome and Nestell 2007).

Middle Jurassic beds of Bajocian age in the central and southern parts of the Huntington quadrangle contain ammonites such as *Tmetoceras*, *Spiroceras*, and *Stephanoceras* (Imlay 1980). H. C. Brooks (oral communication 1970) describes the beds as a series of sheared and slightly metamorphosed massive to thin-bedded graywacke, tuffaceous sandstone, and siltstone that overlie the basal conglomerates of the Jett Creek Member. The late Sinemurian age ammonite, *Cruciloboceras*, has been found near the base of the graywacke sequence (USGS Mesozoic Locs. 29785, 29835). Underlying basal conglomerates contain Early Jurassic, probably Sinemurian age ammonites (USGS Mesozoic Locs. 29846–29851).

Also, in the central and southwestern parts of the Huntington quadrangle, sheared and slightly metamorphosed massive to thin-bedded graywacke, tuffaceous sandstone, and siltstone are exposed (H. C. Brooks oral communication 1970). Minor amounts of interbedded water-laid tuff, conglomerate, quartzose sandstone, limestone, and a few lava flows are also present. These strata rest conformably on up to 100m of red to green conglomeratic beds, which in turn, rest discordantly on Upper Triassic volcanic and sedimentary rocks (Brooks 1967). According to Imlay (1980), these conglomeratic beds contain ammonites of Early Jurassic, probably Sinemurian age. The overlying graywacke series near its base contains the ammonite, *Oruciloboceras*, of late Sinemurian age (Imlay 1980). The graywacke series extends southwestward across the Huntington quadrangle into the southeastern part of the Bridgeport quadrangle. Weatherby Formation beds of Middle Jurassic (Bajocian) age based on ammonites (Imlay 1968, 1973) occur in the Huntington area (locality 2, text-fig. 4). Ammonites of Middle Jurassic (early late Bajocian) age were also recovered at



TEXT-FIGURE 3

Schematic vertical slices through cross sections A-A' and B-B' shown in text-figure 1. See text-figure 1 for explanation of abbreviations.

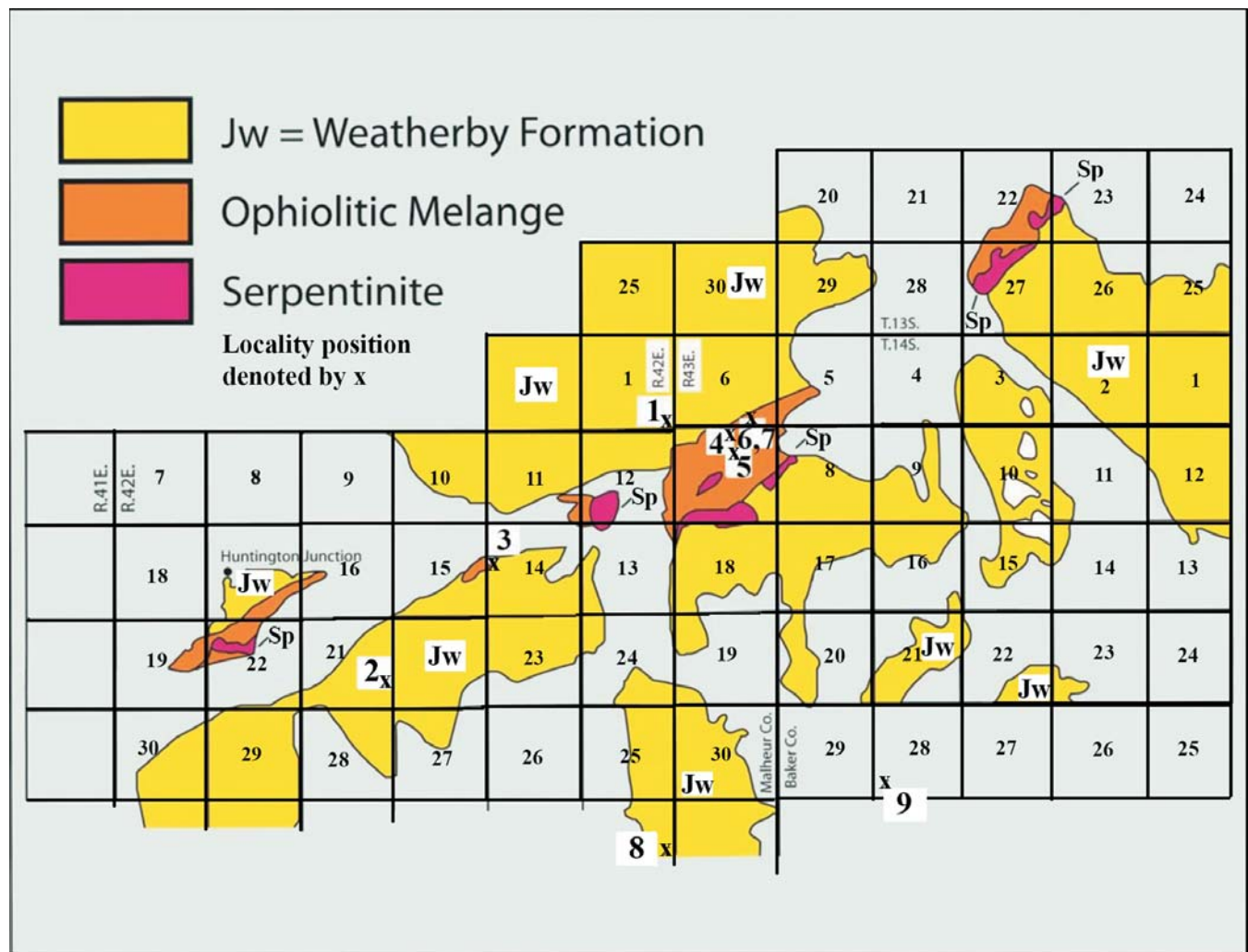
locality 8 (text-fig. 4) based on the presence of *Tmetoceras* (Imlay 1980, p. 31) and by the presence of *Spiroceras* recovered at locality 9 (text-fig. 4, see locality descriptions).

No fossil ages are known for stratigraphic sequences in the north-central part of the bedded Weatherby exposures, but whole rock K-Ar dates of 153.6 and 145.5 Ma were reported by Lowry (1968) for mica schist from the Mine Ridge inlier (MR in text-fig. 1), and university theses on the age of plutons and the provenance/structural history of the Blue Mountains were recently completed by Tumpane (2010) and Ware (2013). The Late Jurassic age of the plutons matches the age of latest deformation in the Baker terrane to the north (Avé Lallemant et al. 1980; Ferns and Brooks 1995). The above comments are meant only to give a brief introduction to the complex geological history of the Olds Ferry terrane and establish a setting for the scarce biostratigraphic data presented in this work.

## MELANGE INLIERS

Northeast-trending zones of mélangé surrounded by the Weatherby Formation were first mapped as “mixed-rock” by Brooks et al. (1976). Variable-sized blocks within the zones range from 1 to 150m in diameter and include chert (text-fig. 5A), limestone, argillite, amphibolite, biotite-schist, serpentinitized peridotite and various types of metamorphosed igneous rocks (Brooks 1979b; Brooks et al. 1982; Hooper et al. 1995). The mixed rock zones can be described as serpentinite matrix-mélangé and can be traced along strike for distances of as much as 19km.

The mélangé zones have been variously interpreted as fault slivers and olistoliths or gravity-slid blocks that were detached from the tectonically active margin of the Weatherby basin (Blome and Nestell 2007). They are herein considered to be tectonic inliers or fault-bounded erosional windows that expose deformed basement rocks underlying the Weatherby Formation. The chaotic nature of the outcrops, combined with mylonitic and metamorphic fabrics, indicates a complex, multiphase tectonic history.



TEXT-FIGURE 4

Distribution of northeasternly-aligned inliers of the Baker terrane near Huntington Junction, eastern Oregon. Numbered x's denote fossil localities. Map modified after Brooks (1979a) and unpublished mapping by Brooks and Blome. Map units: Undifferentiated Tertiary deposits = unpatterned; Weatherby Formation = yellow Jw; Baker melange containing interlayered siliceous argillite, phyllite and chert with minor serpentinite and metavolcanic rocks = orange; serpentinite melange with small inclusions of chert and greenstone = red Sp; melange with mostly mafic greenstones and chert with minor serpentinite = white.

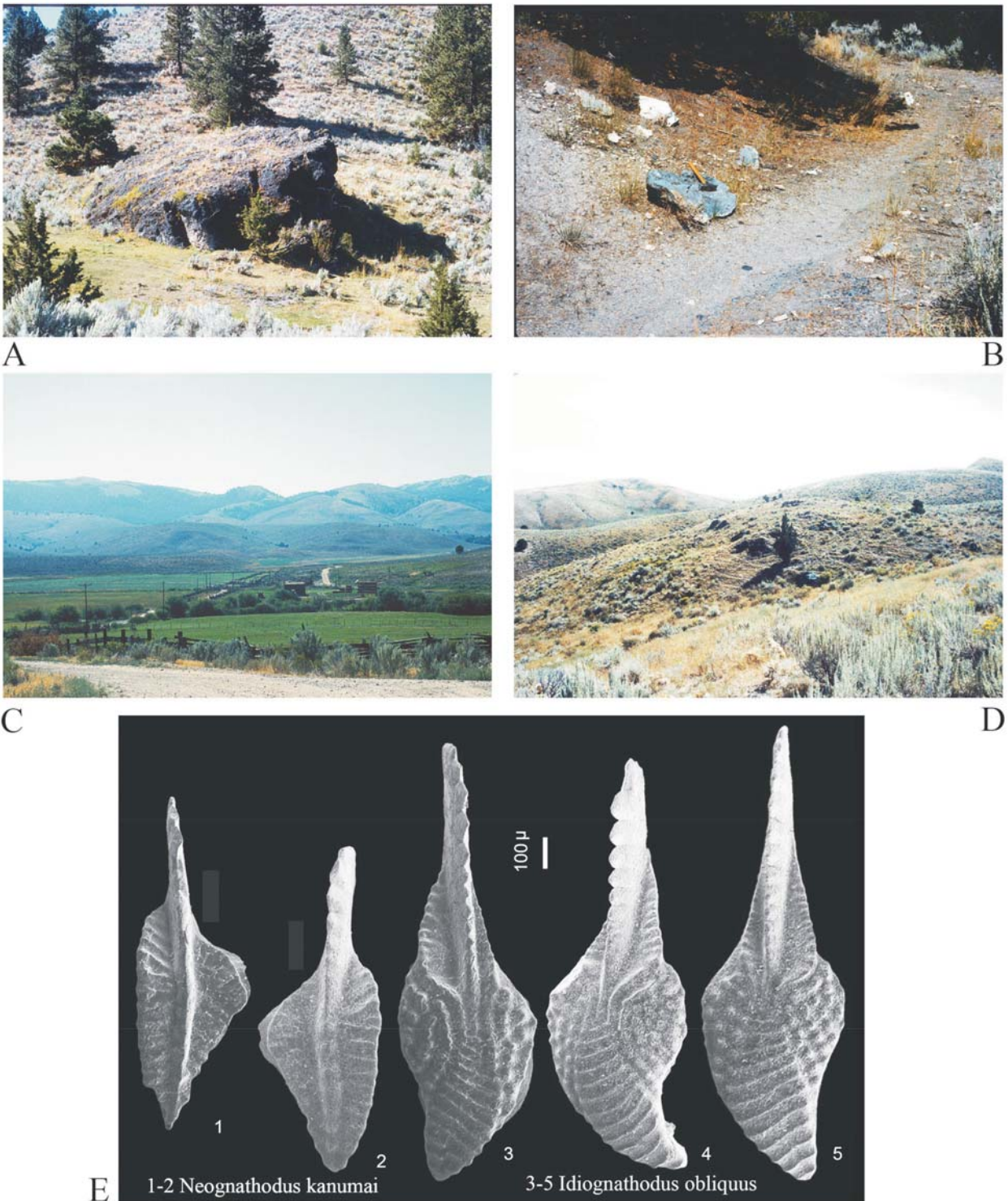
Important inliers include Hereford, Mine Ridge and Huntington Junction (HF, MR and HJ respectively, in text-fig. 1). The northernmost inlier at Hereford (HF) is one of several mélangé zones that are interleaved with Weatherby Formation strata along low angle faults (J. Evans, USGS, Spokane, WA; oral communication 1993). The Hereford inlier extends for 8km and is at least 200m thick where it underlies strata of the Weatherby Formation along a low angle contact (text-figs. 1-3). The inlier is interpreted to be a recumbent limb of an overturned syncline formed by the folded unconformity.

The Mine Ridge inlier (MR in text-fig. 1) is exposed on an east-trending ridge south of the Connor Creek fault (CC in text-fig. 1) near the western end of the Olds Ferry terrane. The inlier extends over an area measuring at least 6km x 3km and is overlain by Tertiary volcanic rocks to the west. The inlier is a serpentinite-matrix mélangé with blocks of harzburgite peridotite, hornblende gabbro, garnet amphibolite, quartz

mica schist and various types of metavolcanic rock, including basalt, andesite and rhyolite (Hooper et al. 1995). Nearby Weatherby Formation conglomerate contains clasts of chert, volcanic rocks and serpentinite. Whole rock K-Ar dates of 153.6 and 145.5 Ma were reported by Lowry (1968) for mica schist from the Mine Ridge inlier (MR in text-fig. 1). The Late Jurassic age matches the age of latest deformation in the Baker terrane to the north (Avé Lallemant et al. 1980; Ferns and Brooks 1995).

The Huntington Junction inlier (HJ in text-fig. 1) is the largest of the northeast trending mélangé zones. The mélangé zone is about 2km wide and based on mapping by H. C. Brooks (oral communication 1993) of the Oregon Department of Geology and Mineral Industries, appears to extend along strike beneath concealing Tertiary lava flows for a distance of 19km. Mélangé blocks and slabs include chert and cherty argillite, peridotite, greenstone and limestone.





TEXT-FIGURE 5

Photographs of conodont and fusulinid localities in the Olds Ferry terrane. Fossil localities are just to the south of the east flowing Burnt River between Hereford and Bridgeport and show the general and specific areas where found. A. Large “chert knocker” in the Weatherby Formation that is located a few hundred meters to the east along the dirt track that passes the one conodont locality. B. Middle Pennsylvanian conodont locality showing several carbonate blocks exposed. These blocks are associated with serpentinite well exposed just to the right of the picture. C. General view facing south from Oregon highway 245 between Hereford on the west and Bridgeport on the east at the intersection of Deer Creek road to the south (Lat.  $44^{\circ}30'17''$  N, Long.  $117^{\circ}57'18''$  W). Fusulinid locality 35O15 (fig. D) is located (SW $\frac{1}{4}$  NE $\frac{1}{4}$  SE $\frac{1}{4}$  Sec. 33, T.12S R.39E, Devil’s Heel Quadrangle, Oregon, Lat.  $44^{\circ}28'34.93''$  N, Long.  $117^{\circ}56'13.34''$  W) near the middle of the picture and just in back of the first group of low hills. The conodont locality 35O14 (fig. C) is located (SW $\frac{1}{4}$  SE $\frac{1}{4}$  NW $\frac{1}{4}$  Sec. 4, T.13S R.39E, Devil’s Heel Quadrangle, Oregon, Lat.  $44^{\circ}27'51.27''$  N, Long.  $117^{\circ}27.49''$  W) in the back set of hills to the upper right in the picture. D. Blocks of scattered limestone pods bearing scarce fusulinids at locality 35O15. E. Middle Pennsylvanian conodonts present in the limestone blocks at locality 35O14.





TEXT-FIGURE 6

Photographs of Weatherby Formation fossil localities showing the general topography variations in exposure and lithology. A. General topography of the area surrounding locality 85CB-032 A-C. B. Most Weatherby Formation exposures are generally low lying with mostly rubble exposed, for example, 86CB-042. C. Base of the measured section of the Weatherby Formation, 85CB-032A-L, Howard Brooks for scale. D. Middle part of the measured section at loc. 85CB-032A-L. Many of the cherty *mélange* block bedding angles are extremely variable, ranging from low to high dip. E, F. Close-ups of thin-bedded phyllitic siliceous mudstone, loc. 85CB-032.



## INLIER FOSSILS

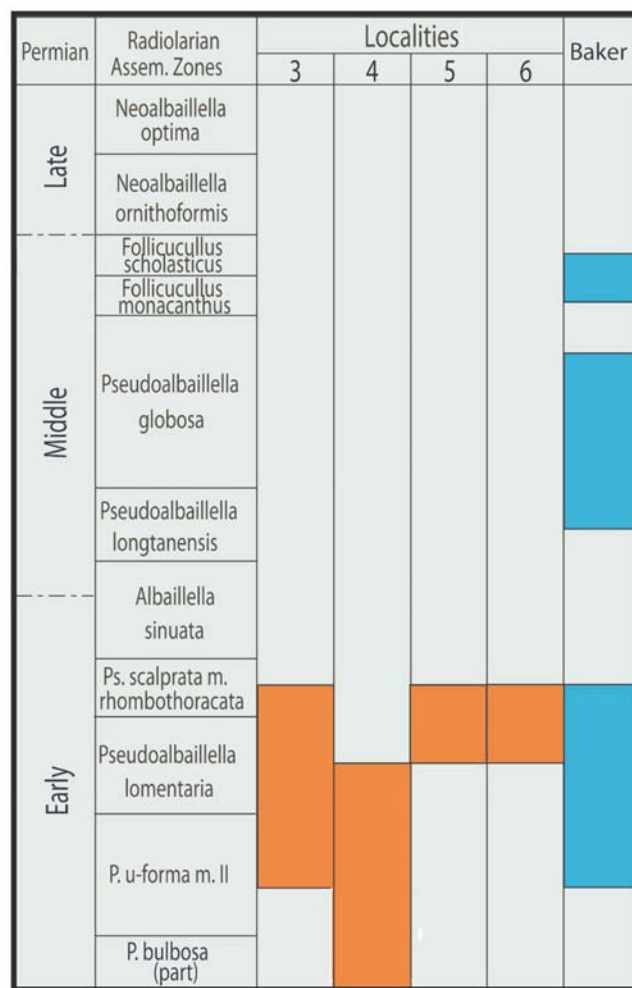
## Hereford Inliers

A significant conodont fauna of latest Atokan/earliest Desmoinesian (Middle Pennsylvanian) age has been collected from small pods of limestone (text-fig. 5B) associated with serpentinite and was discovered by James Evans (USGS) during a regional mapping project. Conodonts include *Idiogonathodus obliquus* Kossenko and Kozitskaya, *Neognathodus kanumai* (Igo) (text-fig. 5E) and an undescribed gondolellid. The CAI (conodont Color Alteration Index) of the conodonts is five and their preservation varies from poor to excellent.

Very poorly preserved fusulinids have been recovered at a second locality (text-fig. 5C, D) where several small limestone pods have yielded a few small pieces of metamorphosed limestone bearing fusulinids. In most of the samples, the fusulinids are hardly recognizable except in a thin section. One small piece (sample 35O15-6) of relatively unmetamorphosed and highly crinoidal limestone contained reasonably preserved fusulinids very similar to *Alaskanella* aff. *A. laudoni* Skinner and Wilde (1966b) (Pl. 1, fig. 4), a species described from float, presumably from the Tahkandit Limestone at a locality north-east of Fairbanks near the Yukon border. The age of *Alaskanella* is considered to be late Early Permian close to the Sakmarian/Artinskian boundary. Herein, this species is referred to *Alaskanella* aff. *A. laudoni* Skinner and Wilde although some workers (Ross 1967; Ross and Ross 2003; Ueno 2006) consider this genus to be a synonym of *Eoparafusulina* Coogan 1960. In the same sample, rare specimens of the trepostome bryozoan genus *Discritella* (Pl. 2, fig. 3), and a form assignable to the cystoporate *Actinotrypella* or *Prismopora* (Pl. 2, figs. 1, 2), were also found. The preservation of these Oregon bryozoans is not good, but the form referred to *Discritella* sp. seems to fit the criteria for the genus. The genus *Actinotrypella* was proposed as an Early Permian form found in the Pamir Mountains (Tajikistan) (Goryunova 1975). The two specimens showing two different cross sections and referred to as *Actinotrypella* sp. could just as well be assigned to the genus *Prismopora* because of the distinctive triangular shape of the zoarium (Pl. 2, fig. 2). Ross (1978) considers *Actinotrypella* to be primarily of Early Permian age and described Permian species of *Prismopora* to be Artinskian or younger. The range of *Prismopora* is Devonian to Permian.

A second piece of highly foliated metamorphosed limestone (sample 35O15-15) contains what appears to be two separate species of fusulinids. The fusulinid specimens are difficult to recognize even on a smoothed and slightly etched (by dilute HCl) surface of cut rock. Twenty random 11/2 x 3 in. rock thin sections were made from the sample, and a few specimens of reasonably well oriented but deformed fusulinids were found (Pl. 3, fig. 1). Two different types of fusulinids are present, one is suggestive of an elongate form of *Pseudofusulinella* or possibly *Triticites* with very thin wall structure, rudimentary chomata, and a very small proloculus (Pl. 3, figs. 2 left; 3 bottom). The other form appears to be some type of primitive schwagerinid with a large proloculus (Pl. 3, figs. 2 right; 3 top). The wall structure of the latter form appears to be keriothecal and thick, but is recrystallized. The age suggested is Early Permian (Asselian).

A third piece of limestone (sample 35O15-18) contains very rare specimens of what appear to be a form of the fusulinid



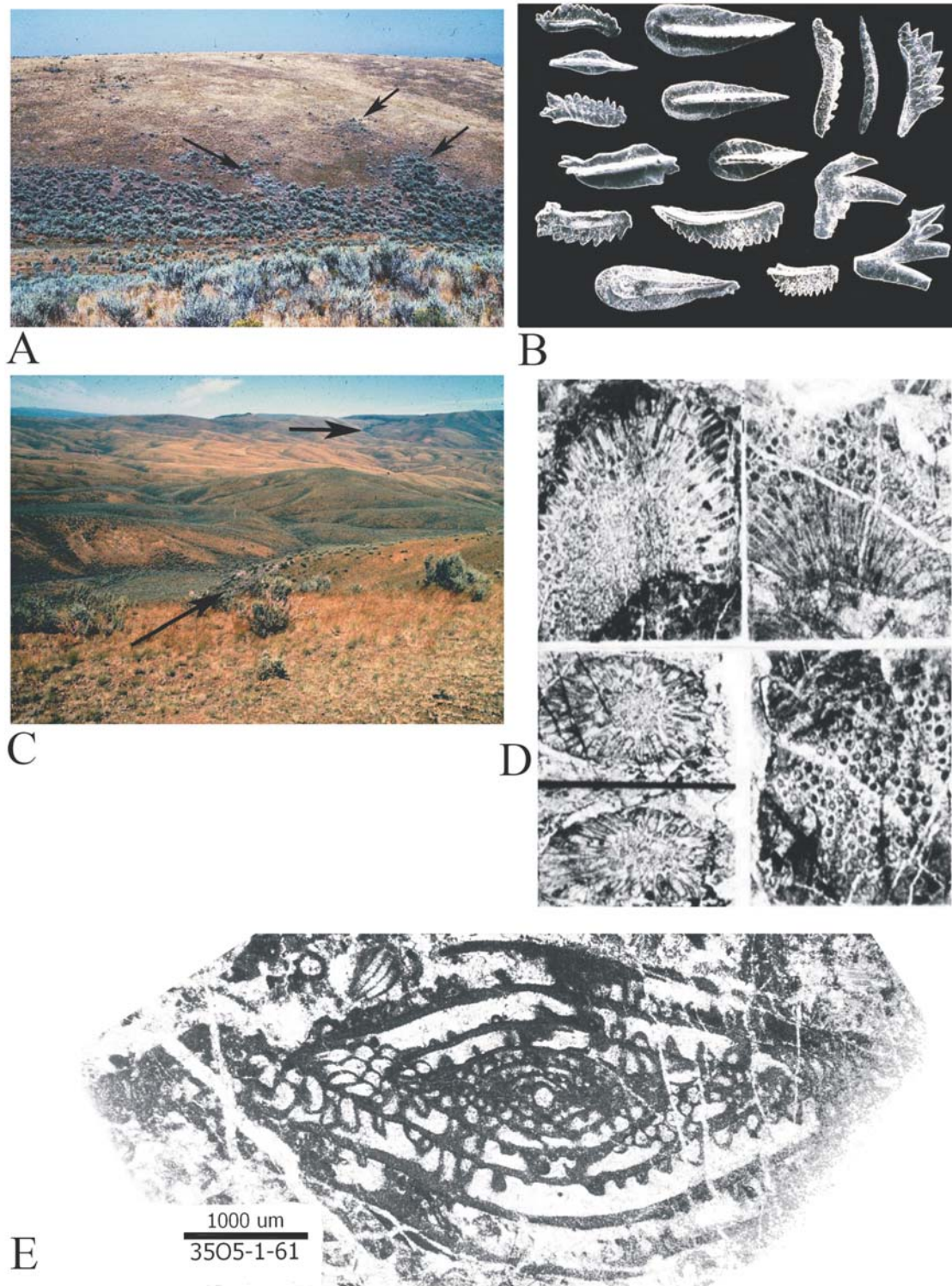
TEXT-FIGURE 7

Approximate age distributions of Permian chert localities in the Olds Ferry terrane as illustrated in text-fig. 4. Radiolarian zonations after Ishiga et al. (1986, 1990).

*Triticites* or even possibly *Dutkevichella*, which would indicate a Late Pennsylvanian age (Pl. 3, fig. 4). This identification is tentative as only two poorly oriented specimens were found in the sample and the wall structure is recrystallized, but appears to be of keriothecal type.

Two other samples contain what is clearly *Chalaroschwagerina* sp. (Pl. 1, fig. 2), *Schwagerina* sp. (Pl. 1, fig. 3) (sample 35O15-5) and *Pseudofusulina?* sp. (Pl. 1, fig. 1) (sample 35O15-1). The presence of the fusulinid *Chalaroschwagerina* indicates a late Sakmarian or early Artinskian (Early Permian) age and indicates a definite affinity to the fusulinids known from the Suplee area of the Grindstone terrane in central Oregon and the Quinn River Crossing area in northwestern Nevada (Skinner and Wilde 1966a).

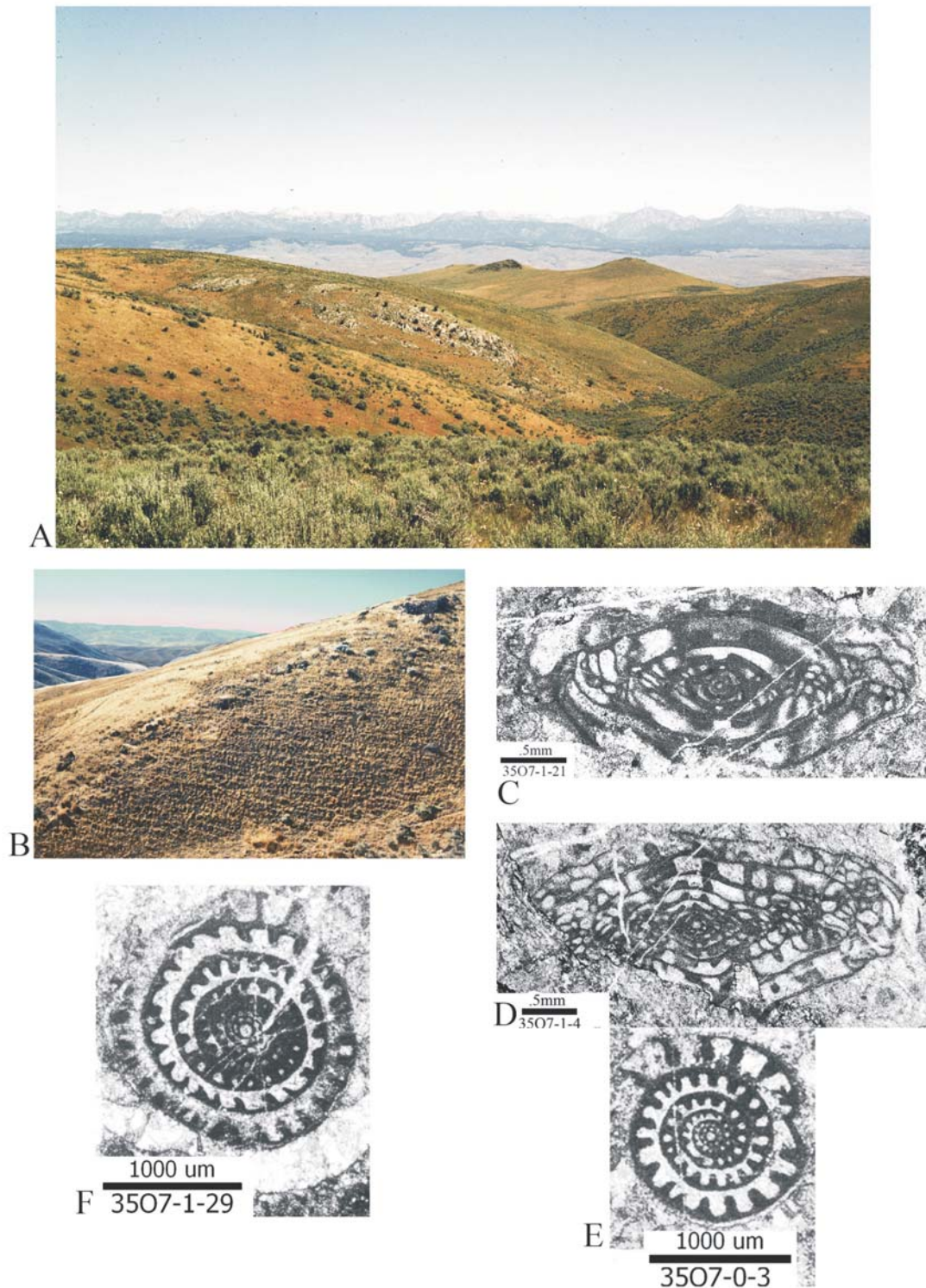
A third biostratigraphically significant locality contains a 12m exposure of interbedded gray to tan, laminated siliceous argillite and dark gray chert at Becker Creek (text-fig. 6C-F) that yielded poorly preserved yet identifiable radiolarians. The bedding dips throughout the section are near vertical (text-fig. 6C-D) and the



TEXT-FIGURE 8

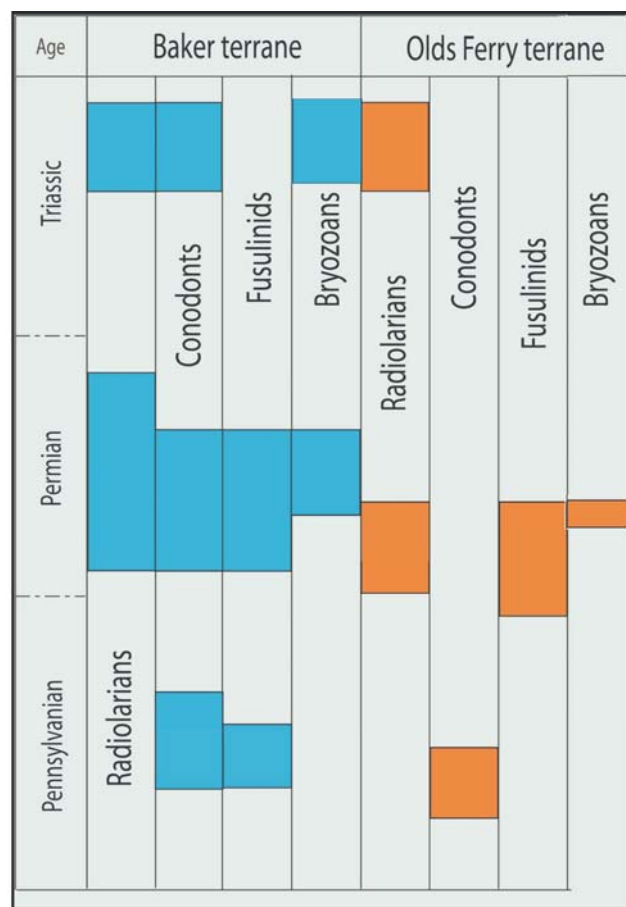
Photographs of two Middle and Upper Triassic localities in the northern part of the Baker terrane in the Virtue Hills area. A. View looking west in the northern part of the Virtue Hills (SW1/4SW1/4SW1/4 Sec. 5, T.10S R.42E; Lat. 44°45'05.68" N. Long. 117°32'44.66 W). Middle Triassic locality bearing *Gladigondolella* (middle arrow in the picture text-fig. 8A; upper right three elements in text-fig. 8B) with other conodont genera. Two other pods of limestone shown by the other arrows in the picture did not yield conodonts. B. Fauna of conodonts recovered from the *Gladigondolella* locality. Magnification 30X. C. View showing the general topography of the north-central part of the Virtue Hills south east of Baker City. Many limestone pods of various sizes, and of Middle Permian and Middle/Late Triassic ages are scattered throughout this area. Upper arrow denoted the approximate locality of text-fig. 9A on Lawrence Creek. *Gladigondolella* locality in the center area of the picture. Lower arrow denotes a large pod of Upper Triassic limestone bearing the trepostome bryozoan *Discritella* and *Epigondolella*. D. Five views of the trepostome bryozoan *Discritella* sp. Magnification 15X. E. *Schwagerina* cf. *S. royandersoni* Thompson, Wheeler and Danner from locality 3505 (see Plate 5 for the rest of the fauna).





TEXT-FIGURE 9

Photographs of two significant fusulinid localities in the northeastern part of the Baker terrane in the Virtue Hills area. Fusulinids from the only Pennsylvanian locality (3507) on the north side of the drainage of Lawrence Creek are also shown. A. View looking north in the northern part of the Virtue Hills (SE1/4NW1/4SW1/4 Sec. 36, T.9S R.41E; Lat. 44°44'15.08" N. Long. 117°38'28.86 W). *Yabeina* locality (3506A) with rare tabulate coral *Zhesipora* is located in the center right of the picture below the main limestone body near the small tree. Powder River Valley and the Wallowa Mountains in the distance. B. View looking west with drainage of Lawrence Creek (NW1/4NW1/4NW1/4 Sec. 11, T.10S R.43E; Lat. 44°42'56.47" N. Long. 117°25'20.46 W) to the left. There are scattered limestone pieces on the hill with the main small body of Pennsylvanian limestone (3507) at the top right of the picture. C. *Fusulinella* cf. *Fusulinella* (*Fusulinella*) *bocki* Moeller, axial section. D. *Beedeina* sp., axial section. E. *Fusulinella* cf. *Fusulinella* (*Fusulinella*) *bocki* Moeller, equatorial section. F. *Beedeina* sp., equatorial section.



TEXT-FIGURE 10  
Comparison of the approximate ranges of various microfaunal taxa and bryozoans in the Baker and Olds Ferry terranes.

multicolored thin-bedded laminations are well developed (text-fig. 6E-F). Despite the radiolarian faunas being poorly preserved, they are the best preserved radiolarians ever recovered from the Olds Ferry terrane. The age of the radiolarians from this short cherty argillaceous section appears to be latest Pennsylvanian (Gzhelian) or Early Permian (Asselian) based on the poorly preserved radiolarians illustrated in Plate 4. These forms belong to the *Pseudoalbaillella bulbosa* and *Pseudoalbaillella u-forma* morphotype II - *Pseudoalbaillella elegans* Assemblage Zones of Ishiga (1986) and Wang et al. (1994). A number of key radiolarian species belonging to the genus *Pseudoalbaillella* were recovered, including *Pseudoalbaillella* cf. *Ps. simplex*, *Ps. aff. Ps. nodosa*, *Ps. cf. Ps. simplex*, *Ps. cf. Ps. elegans* and *Ps. cf. Ps. bulbosa*. Similar forms are known and described from Nevada, Alaska, Japan and Malaysia (Kametaka et al. 2005; Kurihara and Kametaka 2008; Dzulkafli et al. 2012).

### Huntington Junction

Poorly preserved radiolarian faunas of Permian (Asselian) and Late Triassic (Carnian) ages have been collected from chert localities (locs. A and B, fig. 8.4 in Blome et al. 1986) at Huntington Junction. Black chert samples (USGS DR 43-45) from a nearby large chert block (loc. 5 in text-fig. 4) contain poorly preserved radiolarians belonging to the early Sakmarian *P.*

*lomentaria* Range Zone or late Sakmarian *P. scalprata* m. *rhombothoracata* Assemblage Zone (text-fig. 7).

Another chert block (USGS DR 1753-1755) near Becker Creek (loc. 6 in text-fig. 4) contains the diagnostic radiolarians *Pseudoalbaillella scalprata* morphotype *scalprata* Ishiga and *Ps. scalprata* morphotype *postscalprata* Ishiga. Diagnostic forms range from the early Sakmarian *Pseudoalbaillella lomentaria* Range Zone to the latest Sakmarian *Ps. scalprata* m. *rhombothoracata* Assemblage Zone (text-fig. 7; Ishiga 1990). Chert float (USGS DR 1752) from nearby yielded Late Triassic (early or middle Carnian) radiolarians assignable to the *Triassocampe nova* Assemblage Zone of Yao (1982, 1990). Key marker taxa from the chert float include a number of *Pseudostylosphaera* species as well as *Triassocampe japonica* (Nakaseko and Nishimura 1981).

### Bourne subterrane of the Baker terrane

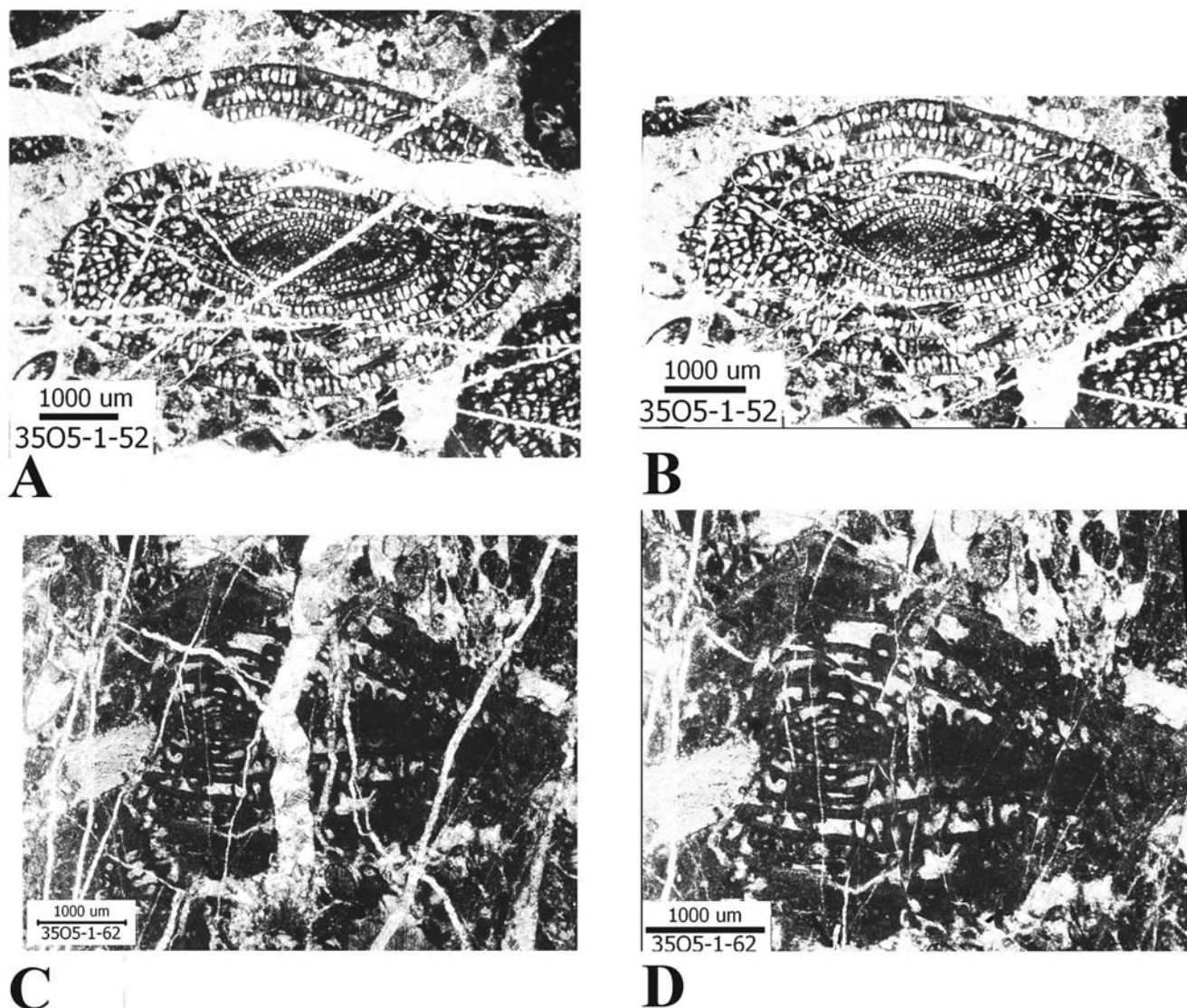
Biostratigraphically significant data from Paleozoic and Triassic age rocks in the both the Baker and Olds Ferry terranes are scarce. Some of the most important fossil data in the Baker terrane have been collected from metamorphosed limestone pods in the Bourne subterrane in the Virtue Hills area southeast of Baker City where fusulinids and conodonts are scarce to abundant in limestone pods that are embedded in radiolarian-bearing chert. The Bourne subterrane data presented herein come from five localities located in the northern part of the Virtue Hills in the northern part of the Oxman and Lawrence Creek 7.5 quadrangles and just south of the Wallowa arc terrane/Bourne subterrane boundary (Schwartz et al. 2010). During field trips over many years, about 10% of several hundred three to five kilogram limestone samples taken from over one hundred limestone pods (mostly in the Oxman 7.5 quadrangle) for conodont processing yielded no Permian and only Triassic (Ladinian to Norian) conodonts.

One locality (3507 in text-figs. 8C; 9B) in the Baker terrane, in the northeastern part of the Virtue Hills on the north side of the drainage of Lawrence Creek, contains Middle Pennsylvanian *Beedeina* (text-fig. 9C, F) and *Fusulinella* (*Fusulinella*) (text-fig. 9D, E). These forms are related to similar forms in Japan and the Canadian Arctic (Nestell et al. 1995). A similar fauna containing Middle Pennsylvanian fusulinids was described from Prince of Wales Island, southeastern Alaska, by Douglass (1971) who noted their affinities to similar age rocks in three areas in Japan. No fusulinids of Late Pennsylvanian or Early Permian age have been found by the authors in the Virtue Hills area. However, in the Baker terrane to the west of Baker City in the Vinegar Hill area (Mullen 1979), thin sections containing undescribed *Pseudofusulinella*, *Schwagerina* and *Boultonia* are present in our collections with clear affinity to the Grindstone subterrane in central Oregon.

Several fusulinid-bearing pods containing Tethyan-related genera, such as *Yabeina* and *Neoschwagerina* are reported from the Virtue Hills area of the Bourne subterrane (Bostwick and Koch 1962; Nestell 1983; Haberfeld and Nestell 1985). Tethyan-related fusulinids including the genus *Neoschwagerina* are also present from several scattered limestone pods in the Elkhorn Mountains northwest of Baker City where these pods have been interpreted as debris from an accreted seamount (Nestell and Nestell 1998; Cruz-Gomez and Nestell 2015).

In the northern part of the Virtue Hills east of Baker City, the diagnostic late Guadalupian Tethyan fusulinid species *Yabeina* cf.





TEXT-FIGURE 11

Fractured specimens of the fusulinids *Yabeina* and *Schwagerina* from locality 3505 showing before and after computer manipulation of the pieces to remove some of the “cracks” resulting from tectonic processes.

*Y. globosa* (Yabe) (Pl. 5) is abundant in a 10–15cm bed of dark blue limestone near the base of a large pod in the mélange (locality 3506A in text-fig. 8A). Much of the pod is recrystallized and careful searching failed to reveal any other fusulinid intervals.

From the Permian of Oregon, only one species of the Tethyan fusulinid genus *Yabeina* has been described, *Yabeina packardi* Thompson and Wheeler, found in a small cobble from Tertiary gravel near Madras in west-central Oregon (Thompson and Wheeler 1942). The genus *Yabeina* is known to be present at several localities in accreted terranes on the western margin of North America from northern California to southern Alaska (Thompson et al. 1950; Stevens et al. 1997; Nestell 1999). Only one species, *Yabeina texana* Skinner and Wilde, has ever been described from cratonic strata of North America where it is

known from several localities in the Guadalupe Mountains area of West Texas (Skinner and Wilde 1955; Tyrrell et al. 2006).

At locality 3506A in the same rock with *Yabeina*, a rare genus of tabulate coral (Pl. 6) is also present that is very similar to the species *Zhesipora permica* Ding described and only known from the Early Permian of Inner Mongolia (Ding et al. 1985).

Some small pods in the general area, such as at locality 3505 located approximately 1km WSW of locality 3506A, also contain faunas with Middle Permian Tethyan-related fusulinid genera such as *Dunbarula* cf. *D. laudoni*, *Lantschichites* sp., *Schwagerina* cf. *S. royandersoni*, and *Yabeina* sp. (Pl. 7, text-fig. 8E). This assemblage is very similar to the one found in accreted terrane rocks exposed in the Granite Falls quarry near Kettle Falls, Washington (Skinner and Wilde 1977c).

One major problem associated with the proper identification of fusulinids in late Paleozoic limestone pods of the Baker terrane of eastern Oregon (and terrane material from other areas) is poor preservation due to deformation by tectonic stresses and medium grades of metamorphism. Often one can see successive stages of calcite filled cracks across individual specimens (text-fig. 11A, C). The same situation is present but not so acute in the preservation of fusulinids in the limestone blocks in the Grindstone terrane where the metamorphism is generally of low grade.

A new way to enhance the identification of these poorly preserved fusulinids is to use modern computer photo manipulation techniques to move parts of the picture of the specimen to "close" cracks and reunite the broken pieces. With careful attention to the generations of stress "cracks", an acceptably assembled picture can be constructed to enhance the proper identification of the specimen. To illustrate the "before and after" results of this technique, four pictures are shown in text-fig. 11. The two original specimens illustrated (text-fig. 11A, C) are from thin sections made from the material from locality 35O5 (see Pl. 7 for other specimens from this locality). The two re-constructed specimens (text-fig. 11B, D) should be easier to identify and permit reasonable approximations to any necessary measurements.

Diagnostic but poorly preserved conodonts (CAI of 5) including *Gladigondolella* cf. *G. tethydis* (Huckriede) (text-fig. 8B) and undescribed gondolellids of Ladinian age are present in a few of the limestone pods (text-fig. 8A, C) from locality 35O114 in the central part of the Virtue Hills (Nestell and Orchard 1991, 2000). A trepostome bryozoan related to *Dyscritella* sp. is present (text-fig. 8D) but scarce in some of the limestone pods also bearing Late Triassic conodonts such as *Epigondolella* cf. *E. abneptus* (Huckriede). One such locality (35O50, denoted by the lower arrow in text-fig. 8C) can be seen in the foreground of the picture. More extensive conodont data from limestone pods in some of the more western areas in the

Baker terrane, such as the Greenhorn subterrane, have been reported by Morris and Wardlaw (1986).

In the Virtue Hills area, the limestone blocks are generally imbedded in argillite or radiolarian chert. Overall, the chert and limestone blocks in the more coherent northern part of the Baker terrane (Bourne subterrane) are mostly of Middle Permian (Guadalupian) and Late Triassic (early Carnian to late Norian) ages (Blome et al. 1986; Pessagno and Blome 1986; Nestell and Blome 1988; Blome and Nestell 1992). Faunas from the western part of the Baker terrane (Greenhorn subterrane) include Middle Permian and Late Triassic radiolarians, and Middle Permian Tethyan-related fusulinids on Dog Creek near John Day (Blome and Nestell 1992). Blome and Reed (1992) described Permian and early (?) Triassic radiolarian faunas from the Grindstone subterrane in central Oregon.

In contrast to the Baker terrane, the Olds Ferry terrane inliers contain Late Pennsylvanian and Early Permian limestone blocks and Permian (Wolfcampian to Guadalupian) and Late Triassic (Carnian) radiolarian-bearing chert and argillite. These occurrences can be related to intervals in the early part of the Middle Pennsylvanian (conodonts), close to the Pennsylvanian/Permian boundary (fusulinids and radiolarians) and to the late part of the Early Permian/early part of the Middle Permian (fusulinids and bryozoans). Fusulinid species indicate that some parts of the Olds Ferry inliers have a clear affinity with the Grindstone subterrane of central Oregon. Although the one outcrop in the Virtue Hills contains Middle Pennsylvanian fusulinids, no fusulinids of Late Pennsylvanian or Early Permian age have been found in this part of the Bourne subterrane.

Early Permian fusulinids from the Olds Ferry inliers do not show Tethyan affinities, but more closely resemble assemblages collected from western part of Greenhorn subterrane near Vinegar Hill and the Grindstone terrane of central Oregon (text-fig. 2). The Greenhorn subterrane, like the Olds Ferry inliers, is characterized by serpentinite-matrix mélange whereas the

## PLATE 1

All specimens from locality 35O15.

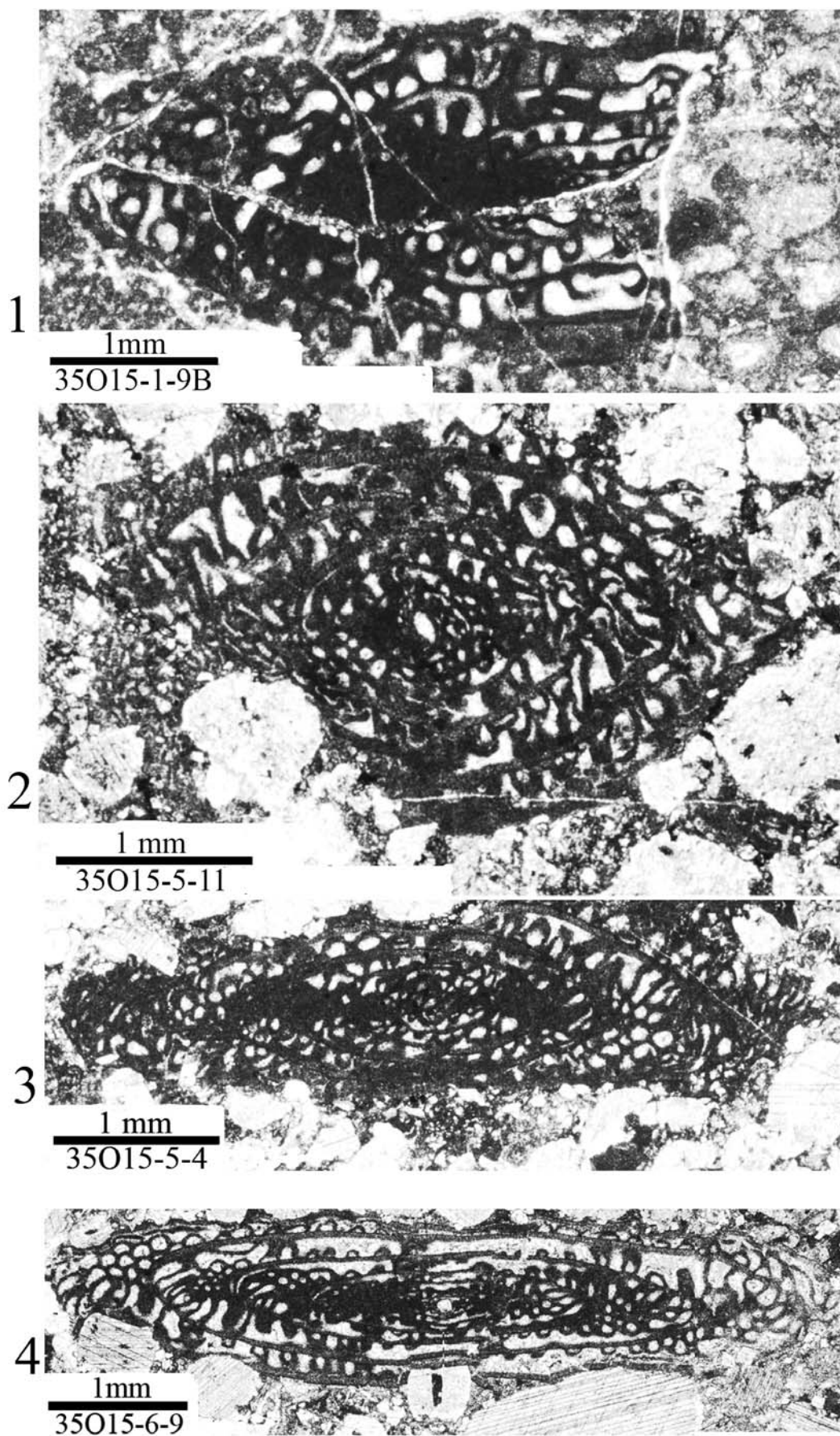
1 *Pseudofusulina* sp.

2 *Chalaroschwagerina* sp.

3 *Schwagerina* sp.

4 *Alaskanella* aff. *A. laudoni* Skinner and Wilde.





Grindstone subterrane is described as an argillite-matrix mélange.

To summarize, Middle Permian faunas of Tethyan-related fusulinids present in mélange of the Baker terrane have been found only in three areas (text-fig 2), the Virtue Hills and Elkhorn Mountains in the Baker City area (Nestell 1983; Nestell and Nestell 1998; Cruz-Gomez and Nestell 2015), and the Dog Creek area just to the southeast of John Day (Blome and Nestell 1992; Nestell and MacLeod 1984). No Tethyan-related fusulinid genera of Middle Permian age appear to be present in the Olds Ferry terrane or in the Grindstone subterrane or the adjacent Izee basin area. Only one fusulinid species of Guadalupian age (late Middle Permian), *Polydiexodina oregonensis* Bostwick and Nestell, has ever been reported from these two areas, and it was found in an isolated limestone block in a Triassic conglomerate at a locality on Big Flat in what has previously been called the Izee terrane (Bostwick and Nestell 1965). In present terminology, this locality would be considered to be part of the western Izee Basin (Schwartz et al. 2010).

The Baker terrane appears to have two distinct types of fusulinid faunas present, Grindstone related ones and distinctly different Tethyan Middle Permian ones. A loose relationship seems to exist between the Baker terrane and the Grindstone subterrane/Izee basin based on fusulinid evidence. However, the presence of Middle Permian Tethyan fusulinids in the Baker terrane that appear to have been “long traveled” and of possible seamount origin suggest a different history for at least the far western parts of the Baker terrane. However, a Mesozoic connection between the Baker terrane and the Olds Ferry terrane appears to be stronger based on radiolarians and ammonites. A summary table of the approximate age ranges of the various microfaunal taxa and bryozoans in the two terranes is presented in text-figure 10.

## CONCLUSIONS

New microfaunal data indicate that mélange-dominated subterrane (Grindstone and Greenhorn) of the Baker terrane

and mélange inliers within the Weatherby Formation of the adjacent Olds Ferry terrane may be tectonically linked. Blocks in the mélange inliers of the Olds Ferry terrane include Pennsylvanian and Lower Permian limestone, and Permian and Upper Triassic radiolarian chert and argillite whose faunal assemblages resemble those found in mélange blocks from the Grindstone and Greenhorn subterrane. Limestone blocks encased in chert and argillite in the Bourne subterrane of the Baker terrane contain Tethyan-related fusulinid assemblages that are distinct from the faunas in the inliers in the Weatherby Formation.

Sedimentary rocks in the Baker terrane are characterized by a tectonic mixture of Devonian to Triassic age limestone and chert that is typically altered to marble and metachert. Baker terrane lithologies commonly exhibit tectonic shear fabrics, and regional greenschist and higher metamorphic grades, indicating subduction in an accretionary complex. Faunas from the Greenhorn subterrane in the western part of the Baker terrane include Middle Permian and Late Triassic radiolarians and Middle Permian Tethyan-related fusulinids from the Miller Mountain and Frenchy Butte mélange areas. Faunas in the central Greenhorn subterrane (Aldrich Mountains) and eastern Bourne subterrane (Virtue Hills) include Middle Permian (Guadalupian) and Late Triassic (Carnian and Norian) radiolarians, Devonian to Late Triassic conodonts (CAI's of 5-6), Middle Permian fusulinids and tabulate corals, and rare Late Triassic trepostome bryozoans.

The Lower and Middle Jurassic Weatherby Formation (Olds Ferry terrane) is composed largely of volcanic wacke, siltstone, and argillite. Rocks of the Weatherby Formation depositionally overlie the contact between mélange-rich Devonian to Triassic rocks (Baker terrane) to the north and Triassic volcanic arc rocks of the Huntington Formation (Olds Ferry terrane) to the south. Blocks of ophiolitic mélange containing Pennsylvanian and Lower Permian limestone and Permian (Cisuralian to Guadalupian) and Upper Triassic (Carnian) radiolarian-bearing chert and argillite are erosional inliers in the bedded Weatherby sequences.

## PLATE 2

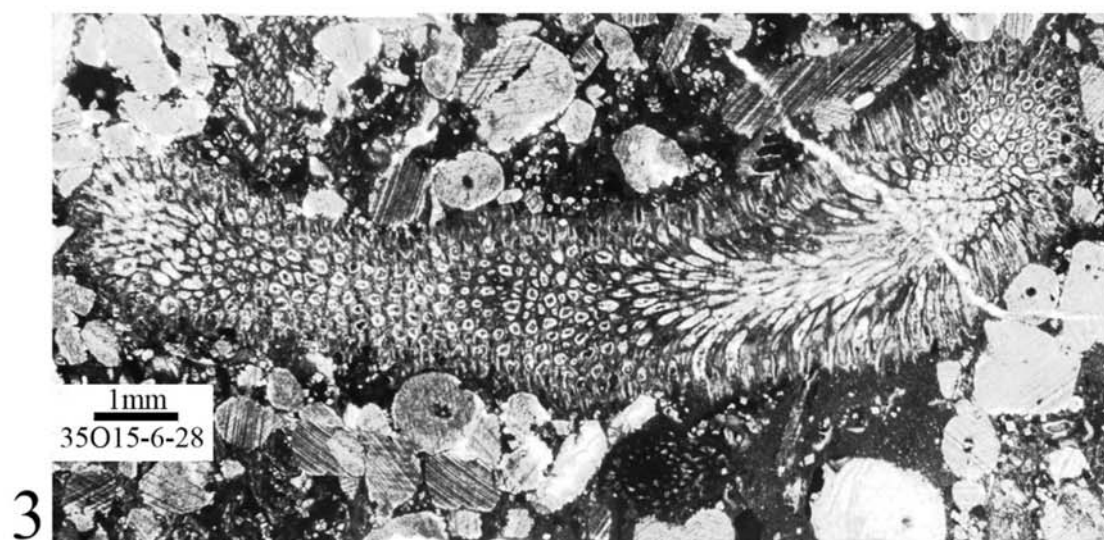
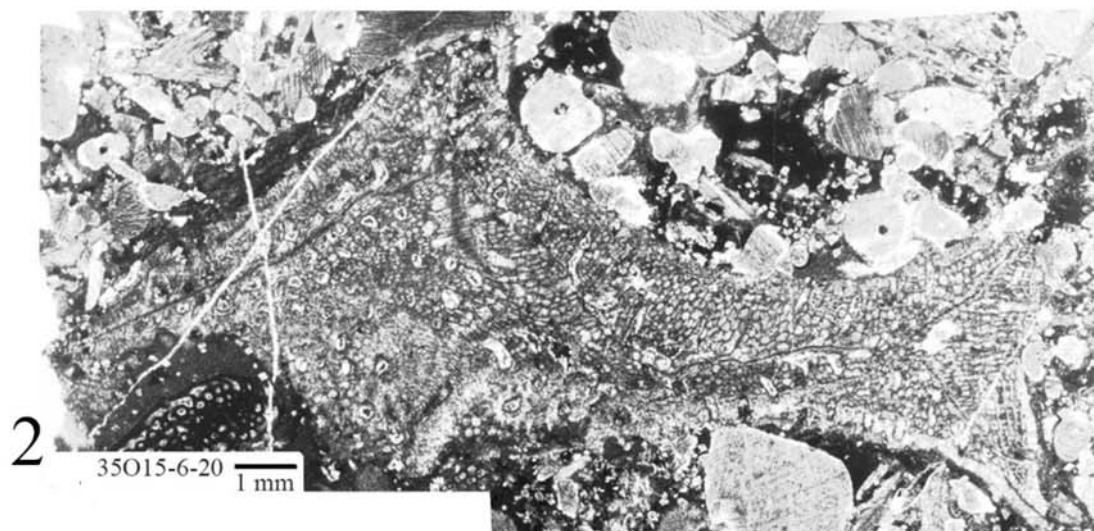
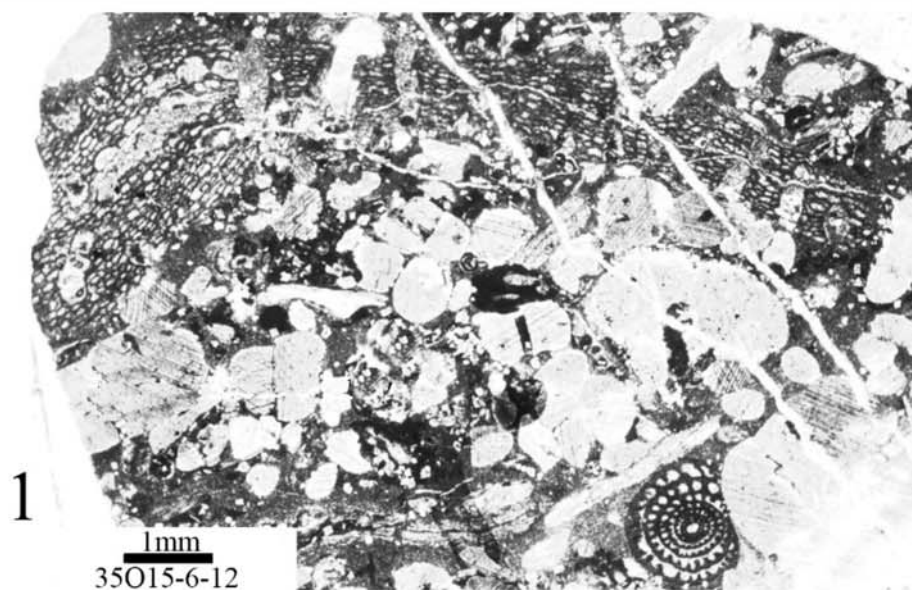
All specimens from sample 35O15-6.

1 *Actinotrypella* ? sp., vertical section.

3 *Discritella* sp.

2 *Actinotrypella* ? sp., horizontal section.





Regional compressional deformation in the Late Jurassic resulted in emplacement of blocks of older mélangé debris derived from the Baker terrane into Weatherby Formation strata. Compressional deformation also resulted in southeasterly directed folding of the Baker terrane and Weatherby Formation. The unconformity between the Baker and Weatherby rocks was folded into a regional syncline, the lower limb of which is recumbent and the upper limb of which is overturned to the southeast. The Connor Creek fault marks the surface of the Baker terrane - Weatherby Formation unconformity and observed attitudes of this contact vary from horizontal to vertical to overturned depending on the depth of exposure and location of the fold.

The presence of Early Jurassic (Sinemurian) ammonites in bedded Weatherby Formation sequences depositionally overlying the mélangé inliers indicates that the chaotic structure of the mélanges had begun developing sometime before the Early Jurassic. Late Jurassic K-Ar ages of muscovite in schist from the Mine Ridge inlier (Lowry 1968) suggest disruption and recrystallization of components during the Late Jurassic deformation.

#### ACKNOWLEDGMENTS

The study of the geology and biostratigraphy of the accreted terranes of central and eastern Oregon began for the authors when both of them were graduate students, Blome under Emile Pessagno (University of Texas at Dallas), and Nestell under David Bostwick (Oregon State University). Later, the merging of efforts and many months of field work by the authors during the summers of the 1980s and 1990s in a time when private and public property access was not much of a problem resulted in much data accumulation. Several publications have resulted from this work and there are yet more data to be published, especially about the radiolarians and foraminifers of the Baker terrane. This paper is meant to be a companion to the paper about the Grindstone terrane of Blome and Nestell (1991). This particular study has benefited especially from many discussions with Howard Brooks, Mark Ferns, Jim Evans, Tracy Vallier, and Norm Silberling. Bruce Wardlaw, Lance Lambert, Ernest

Gilmour, Charles Ross, and Vladimir Davydov contributed comments about the faunas. We especially thank Mark Ferns, Calvin Stevens, Bruce Wardlaw, and Galina Nestell for their careful and insightful reviews, but the authors take full responsibility for the interpretations presented here. We also thank Elizabeth Browsers, Robert Horton and David Ferderer of the USGS in Denver for their help in expediting the current USGS manuscript review process. We also thank Jim Vigil for processing the radiolarian chert. All field photographs and photomicrographs were taken by the authors.

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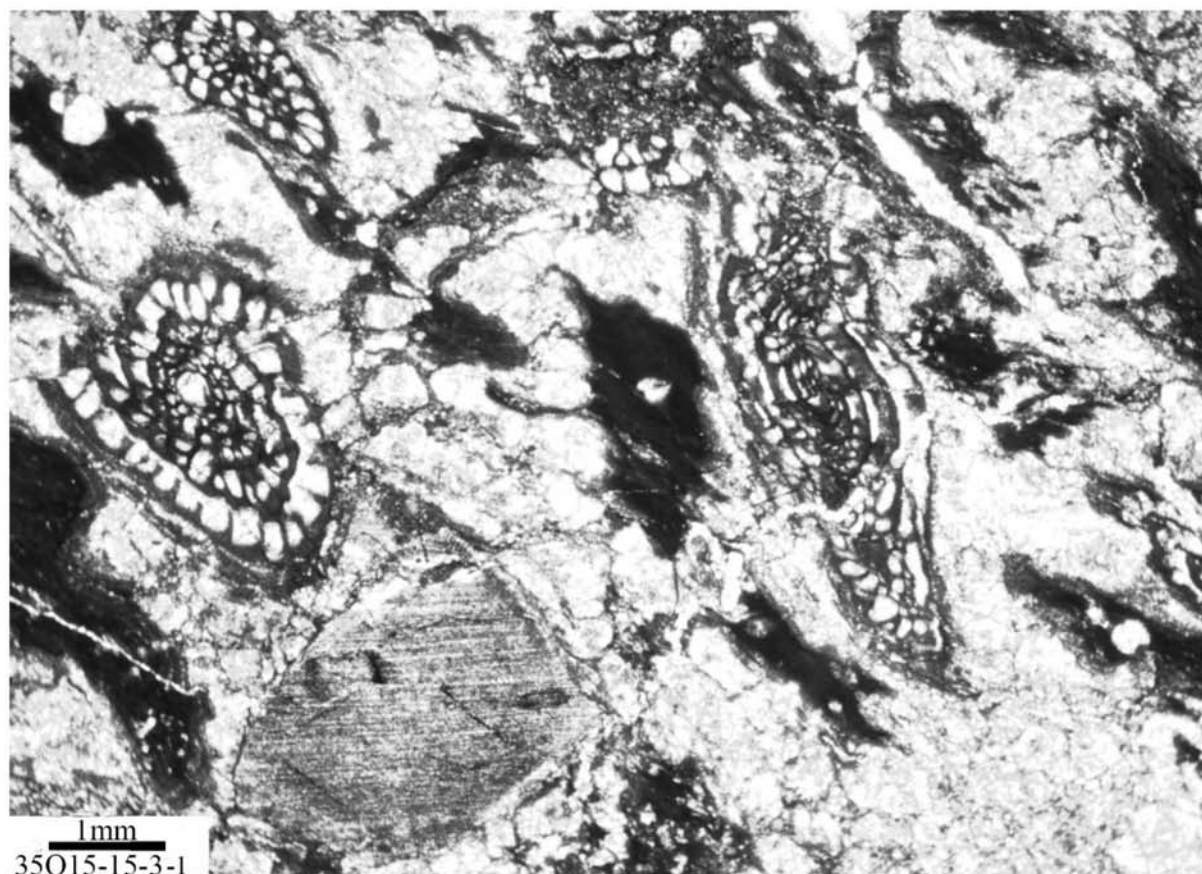
#### PLATE 3

- 1 General metamorphic texture of sample 35O15-15 with large proloculus schwagerinid on left side of section
- 2 Equatorial views of *Pseudofusulinella* ? sp. (left side) coated with possible algae and *Schwagerina* sp. (right side)
- 3 Equatorial views of *Pseudofusulinella* ? sp. (bottom) and *Schwagerina* sp. (top). These two tentative identi-

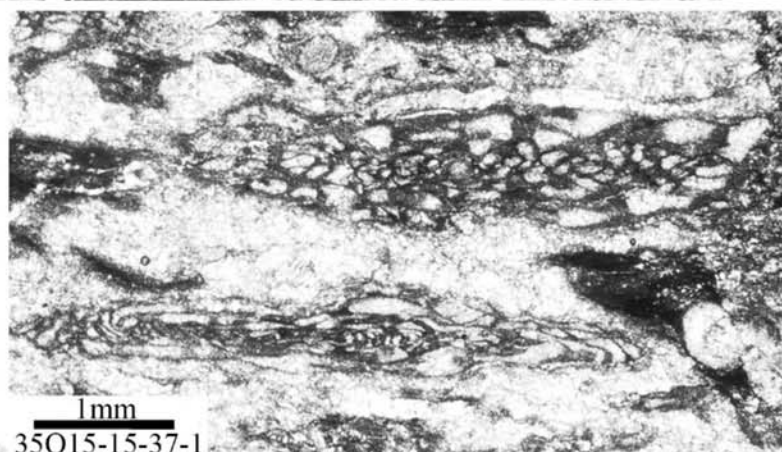
fications are problematic because of the poor preservation. In some sections, the forms with a large proloculus and referred to *Schwagerina* sp. show a keriothecal wall that supports the age as probably Asselian or Sakmarian.

- 4 *Triticites* sp. or possibly *Dutkevichella* sp.

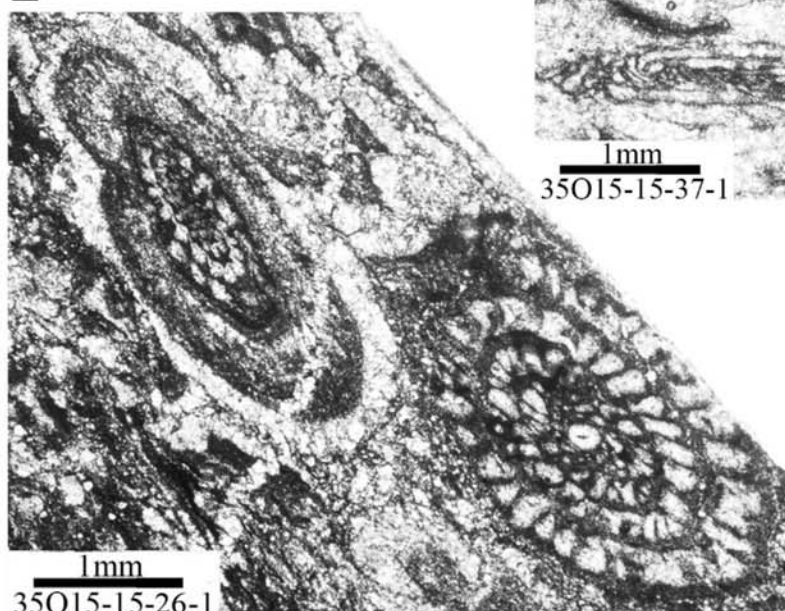




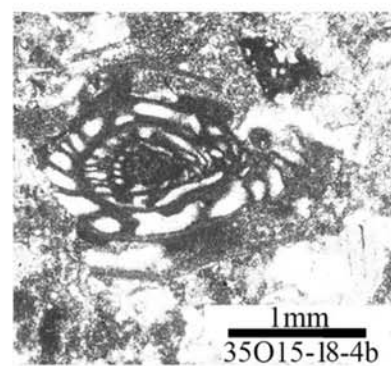
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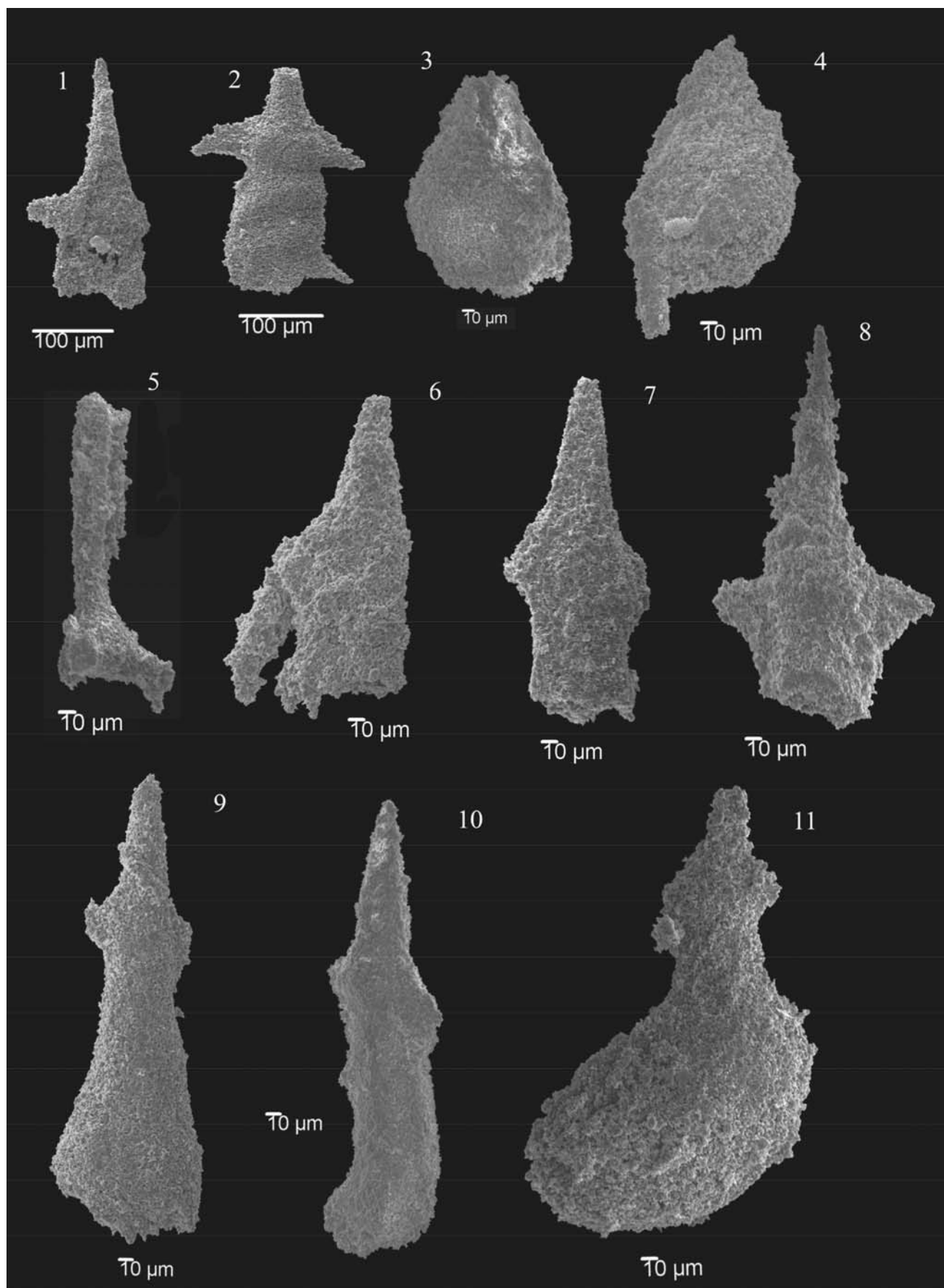
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#### PLATE 4

All specimens are from samples 86CB-033A-I (text-fig. 4, locality 4) taken in a 12 meter section of Weatherby Formation interbedded dark gray chert, dark gray to tan argillite, and siliceous mudstone, west of Becker Creek, USGS Birch Creek Meadow 7.5 quadrangle in western Oregon. These radiolarians were specifically illustrated as they are the best preserved late Paleozoic age specimens ever recovered from strata of the Weatherby Formation. Each illustration bears its own micro scale.

- |  |  |
|--|--|
| 1 <i>Pseudoalbaillella</i> cf. <i>Ps. simplex</i> Ishiga and Imoto, x200, sample 86CB-033I (USGS DR-055) | 7 <i>Pseudoalbaillella</i> cf. <i>Ps. simplex</i> Ishiga and Imoto, x350, 86CB-033I, (USGS DR-055) |
| 2 <i>Pseudoalbaillella</i> aff. <i>Ps. nodosa</i> Ishiga, x200, sample 86CB-033I (USGS DR-055)           | 8 <i>Pseudoalbaillella</i> cf. <i>Ps. simplex</i> Ishiga and Imoto, x350, 86CB-033G (USGS DR-053)  |
| 3 <i>Pseudoalbaillella</i> ? sp., x350, sample 86CB-033G (USGS DR-053)                                   | 9 <i>Pseudoalbaiella</i> cf. <i>Ps. elegans</i> Ishiga and Imoto, x350, 86CB-033F (USGS DR-052)    |
| 4 <i>Pseudoalbaillella</i> ? sp., x350, sample 86CB-033G (USGS DR-053)                                   | 10 <i>Pseudoalbaiella</i> cf. <i>Ps. elegans</i> Ishiga and Imoto, x350, 86CB-033F (USGS DR-052)   |
| 5 <i>Quadriremis</i> ? sp., x350, sample 86CB-033F, (USGS DR 052)  | 11 <i>Pseudoalbaillella</i> cf. <i>Ps. bulbosa</i> Ishiga, x350, 86CB-033G (USGS DR-053).          |
| 6 <i>Pseudoalbaillella</i> sp., x350, sample 86CB-033D, (USGS DR-050)                                    |  |





partment of Geology and Mineral Industries Geological Map Series GMS-7, scale 1:250,000.

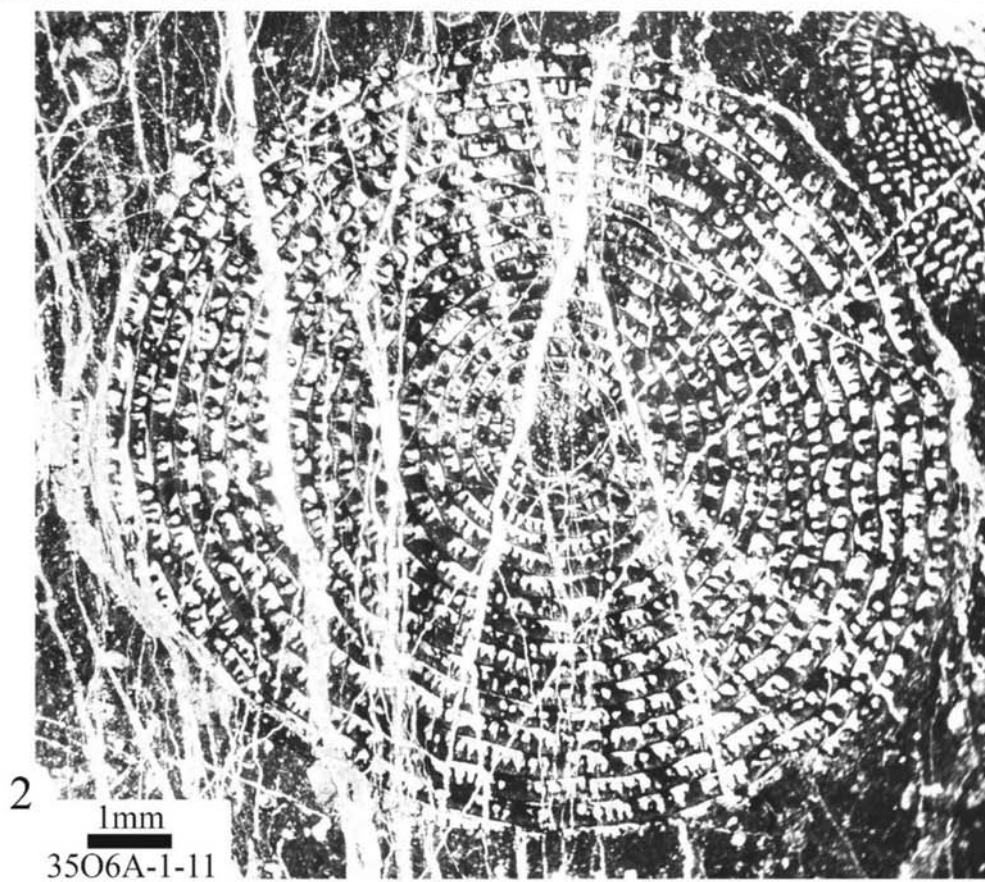
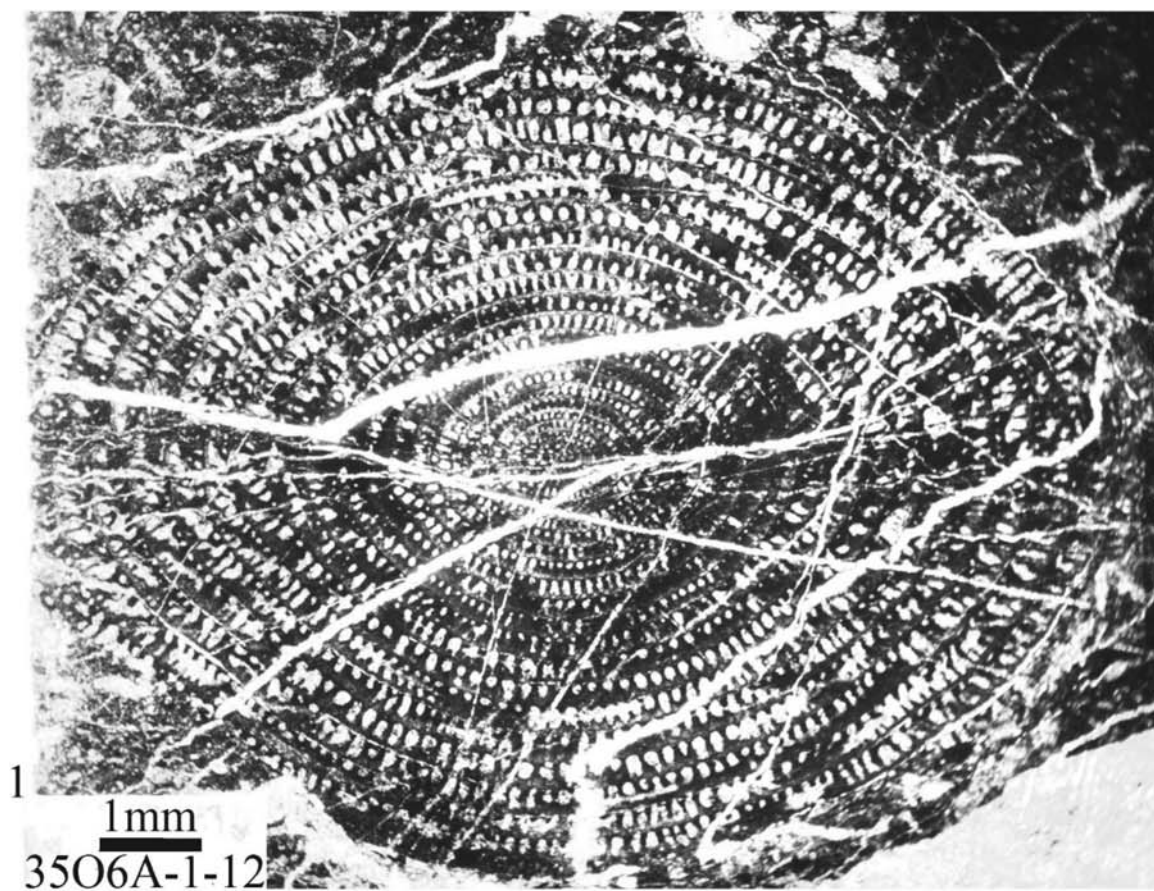
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## PLATE 5

1 Axial section of large fusulinid *Yabeina* cf. *Y. globosa* (Yabe) from locality 35O6A that is abundant in a thin 10-15cm bed near the base of large pod of limestone shown in text-figure 8A

2 Equatorial section of another specimen.





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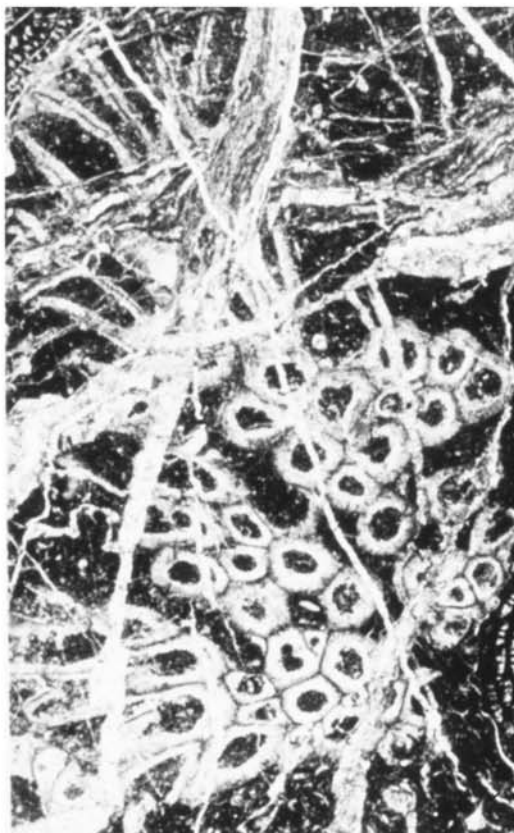
## PLATE 6

Magnification 15X.

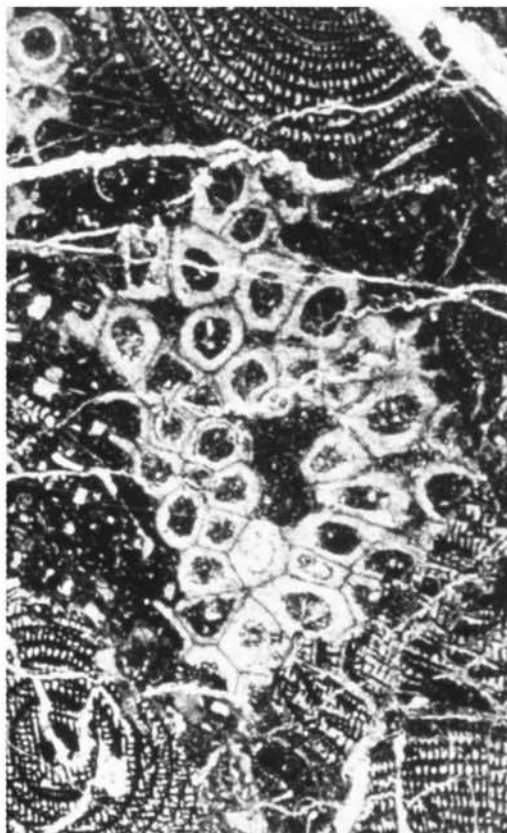
1,2 Transverse sections across rare tabulate coral *Zhesipora* sp. found with the fusulinid *Yabeina* cf. *Y. globosa* (Yabe) at locality 35O6A. The Oregon coral is very similar to *Z. permica* Ding known only from the Lower Permian of Inner Mongolia

3 Vertical section of corallites.

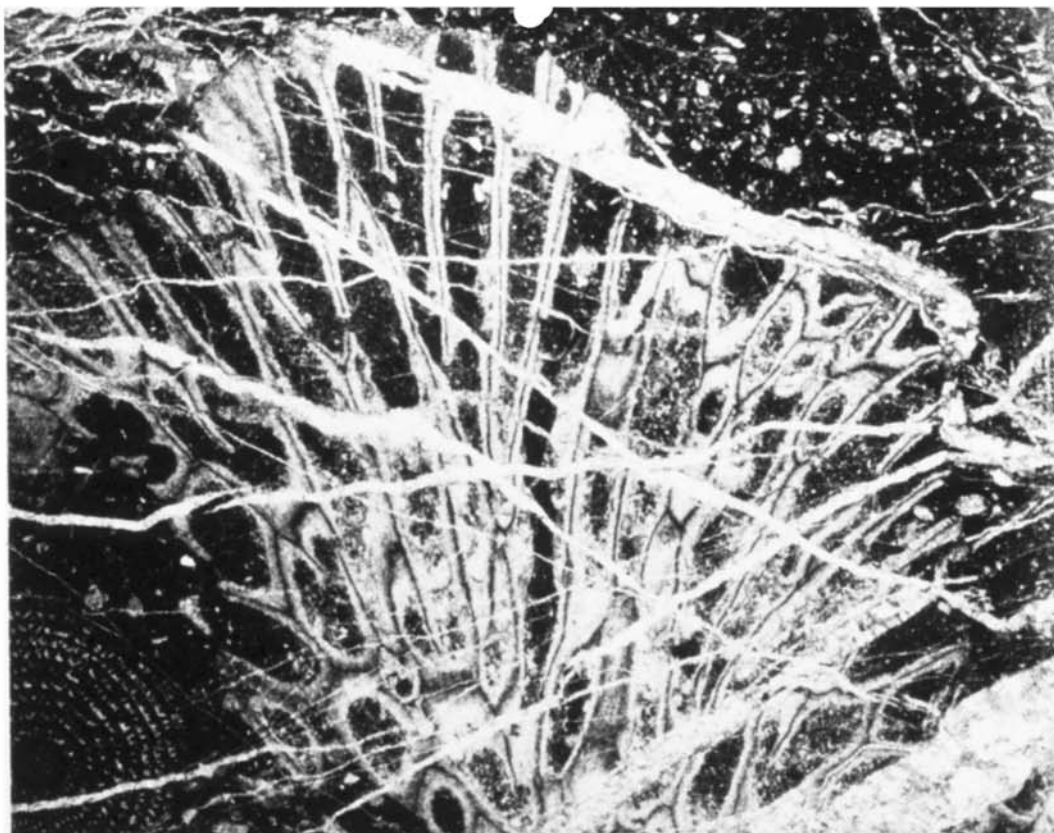




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## PLATE 7

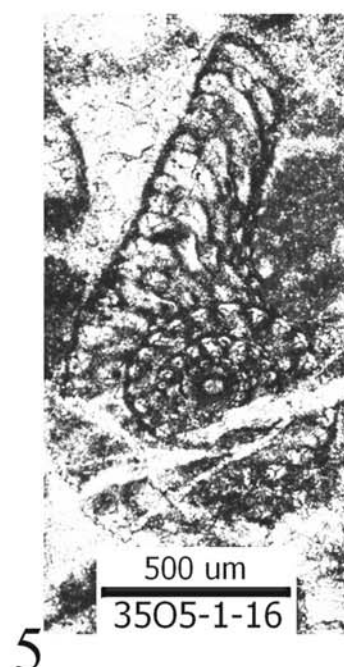
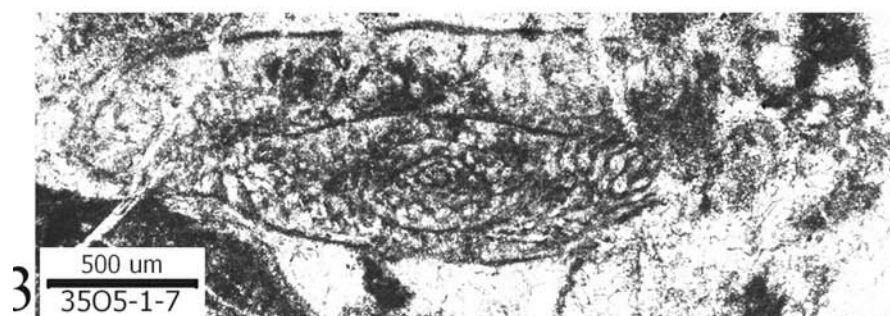
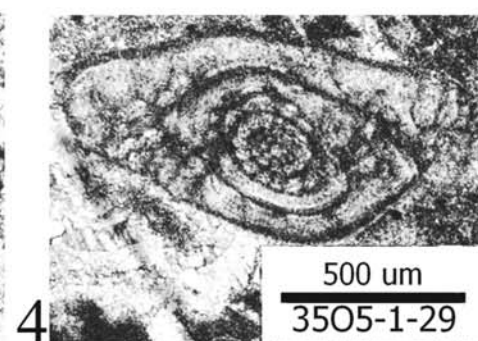
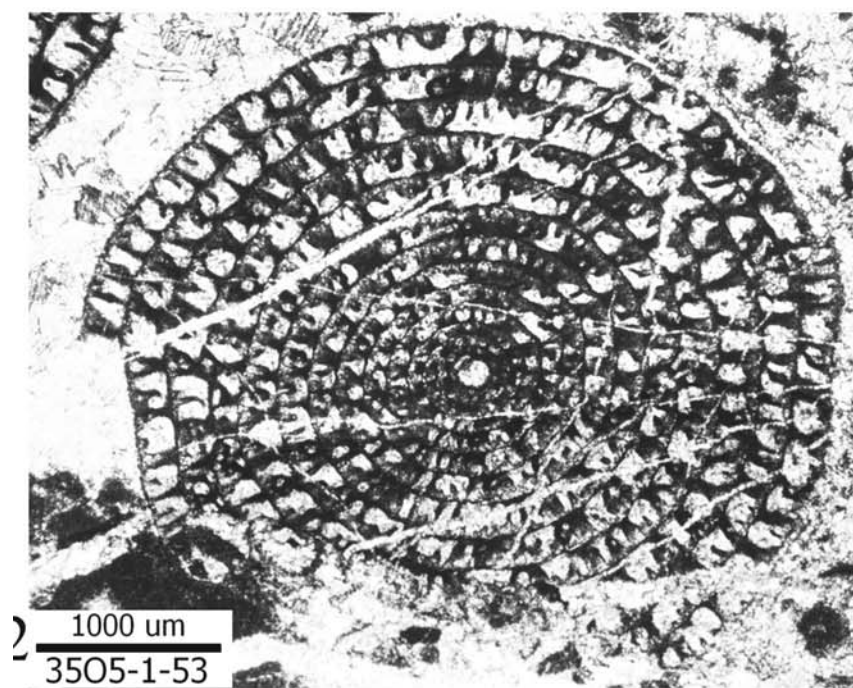
Specimens from locality 3505 in the northern part of the Virtue Hills at road intersection approximately one kilometer W/SW of locality 3506A (SW1/4SE1/4SE1/4 Sec. 35, T.9S R.41E; Lat. 44°43'52.17" N. Long. 117°39'08.17" W).

1,2 Axial and equatorial sections of *Yabeina* sp.

3,5 Axial and equatorial sections of *Lantschichites* sp.

4 Axial section of *Dunbarula* cf. *D. laudoni* Skinner and Wilde.







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APPENDIX 1

Blome locality descriptions.

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Locality 1: Early Jurassic (Pliensbachian) ammonite locality. USGS Becker Creek 7.5 quadrangle, T.14S., R. 42E., SE1/4 SE1/4, sec. 1, far SE corner. Ammonite collected by H. C. Brooks and identified by R. W. Imlay (Brooks 1967).

Locality 2: Middle Jurassic (Bajocian) ammonite locality. USGS Becker Creek 7.5 quadrangle, T.14S., R. 42E., SE1/4 SE1/4, sec. 21. Ammonite collected by H. C. Brooks and identified by R. W. Imlay (Brooks 1967).

Locality 3: 85CB-030A-C (USGS DR-039-41). USGS Bridgeport (15') quadrangle, T.14S., R.42E., SW1/4 NW1/4, Sec. 14. Weatherby Formation, sample 85CB-030A dark green chert, 030B and 030C dark blue/black chert, all samples collected are float. Samples (FR-80-85A-C = MR 2804-2806) collected by Francois Roure (Blome et al. 1986, p. 91), approximately 1.0mi. to the east in SE1/4 NE1/4, sec. 14, near boundary separating sections 14 and 15, contain Late Triassic (Carnian/Norian) radiolarians.

Locality 4: 85CB-033A-L (USGS DR 047-58). USGS Birch Creek Meadow 7.5 quadrangle, NE1/4 NW1/4, Sec. 7, T.14S., R.43E., west of dirt road and Becker Creek. Weatherby Formation, approximately 12m (40ft.) of interbedded dark gray chert and dark gray to tan argillite and siliceous mudstone, argillite very thin-bedded (0.2cm to 1.0cm), whereas chert beds to 5.0cm. thick, beds weather rust brown to orange in color, very ribbon-like in appearance, argillite increases in abundance topographically up-section. Samples DR-047 and -048 from slide blocks, rest of outcrop insitu, all samples collected topographically upsection.

Locality 5: 85CB-032A-C (USGS DR-043-45). USGS Birch Creek Meadow 7.5' quadrangle, boundary between the SW1/4 NE1/4, Sec. 7, T.14S., R.43E., east of gravel road and Becker Creek. Weatherby Formation, all black-colored chert from large chert knocker, DR-043 float, -044 and -045 collected directly from knocker.

Locality 6: 93CB-020 (USGS DR 1752). USGS Birch Creek Meadows (7.5) quadrangle, SW1/4 SE1/4, Sec. 6, T.14S., R.43E., just north of the boundary separating Sec. 6 and 13 and directly west of dirt road and 0.2 mi. east of elevation marker 4281. Dark blue/green chert float from chert rubble, rubble intermixed with minor argillite.

Locality 7: FR-80A-C (USGS MR 2804-2806). Samples from chert blocks in Jurassic flysch, Olds Ferry terrane. Collected by Francois Roure. USGS Bridgeport quad. (15'): SW1/4 SE1/4, Sec. 6, 15T.14S., R.42E. just north of the boundary separating Secs. 6 and 13.

Locality 8: Locality 140 (USNM 27583) of Imlay 1973. Collected by Ernest Wolff 1958. Nearly one mile east of Becker Creek in north-central part of NE1/4 SE1/4, Sec. 26, T.14S., R.42E., Bridgeport 15 min. quad. Malheur County, OR. Unnamed beds.

Locality 9: Locality 143 (USNM 29782) of Imlay 1973, Collected by H. C. Brooks, N.S. Wagner, W. O. Ross and R. W. Imlay 1969. Near elevation of 4,193 ft. on south side of road in SW1/4SW1/4, Sec. 28, T.14S., R.43E., Huntington quad., Baker County, OR. Unnamed beds.