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COVER PHOTO

An example of the ammonite genus *Euhoploceras* from the Snowshoe Formation in the Suplee area, east-central Oregon. Maximum diameter of specimen is 13.5 cm. See article beginning on next page.

OIL AND GAS NEWS

Columbia County:

Reichhold Energy Corporation continues to carry out exploratory drilling in Columbia County, most recently spudding Crown Zellerbach 32-26 about 11 mi southeast of production at the Mist Field. This well, projected for 6,500 ft, is located in sec. 26, T. 5 N., R. 4 W.

The company also anticipates redrilling two existing wells at Mist: Columbia County 4 and 13-1.

Douglas County:

Florida Exploration Company of Houston has begun drilling northwest of Roseburg in Douglas County. A Montgomery rig from California spudded the well, Florida Exploration Company 1-4, on April 6 and is drilling toward a proposed depth of 10,000 ft. The well is in sec. 4, T. 21 S., R. 6 W. The operator has also applied to drill a second well in Douglas County (see table below).

Malheur County:

It has been over 20 years since an oil and gas well has been drilled in northern Malheur County, although several of the earlier wells had shows of gas. Z & S Construction Company of Kimball, Nebraska, will soon bring the oil and gas search back to the Vale area with a well to be drilled in sec. 9, T. 19 S., R. 44 E. The proposed depth is 4,850 ft.

Recent permits:

Permit no.	Operator, well, API	Location	Status
210	Reichhold Energy Crown Zellerbach 34-26 009-00101	SE¼ sec. 26 T. 5 N., R. 4 W. Columbia County	Permit issued
211	Reichhold Energy Crown Zellerbach 32-26 009-00102	NE¼ sec. 26 T. 5 N., R. 4 W. Columbia County	Spud 3/26/82
212	Z & S Construction Recla 1 045-00023	SE ¼ sec. 9 T. 19 S., R. 44 E. Malheur County	Application
213	Florida Exploration Co. USA 1-25 019-00015	NW ¼ sec. 25 T. 24 S., R. 8 W. Douglas County	Application

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CONTENTS

Jurassic shallow marine invertebrate depth zones, with exemplification from the Snowshoe Formation, Oregon

by David G. Taylor, Earth Sciences Department, Portland State University, Portland, Oregon 97207

INTRODUCTION

The Jurassic System historically has been associated with the development of concepts important for paleontology. Its classic terrane, in Europe, was the proving ground for such principles as faunal succession (William Smith), refined faunal zonation (Albert Oppel) and stages (Alcide d'Orbigny), and for the conceptualization of facies (Armanz Gressly). Jurassic molluscan-dominated shelly faunas have been the source of a profusion of monographs and even some detailed paleoecologic studies. Yet, to this day we have no comprehensive model for the shelly invertebrate depth zonation in the Jurassic shallow marine environment. Provinciality in the Jurassic was modest, which suggests that we may seek a general model of the paleobathymetric faunal distribution, just as has been accomplished for parts of the Paleozoic (Berry and Boucot, 1972; Boucot, 1975).

Our accumulated knowledge of Jurassic paleontology centers on Europe. It is the only region where marine invertebrate faunas are well known and, with a few exceptions, is the source for detailed paleoecologic study. Our knowledge of the Jurassic is weighted heavily toward the epeiric environment, which typifies northwest Europe.

The Jurassic of the Western Cordillera of the United States consists of thick eugeosynclinal sequences that have received comparatively little study paleontologically, with the notable exception of the numerous articles by Imlay (1980, for summary). The neglect may have resulted partly from the belief by many that eugeosynclinal terranes are unsuited for refined paleontologic work. This attitude is best exemplified in the statement of a prominent Jurassic stratigrapher contrasting the Jurassic in the Western Interior with the West Coast sequences: "The facts attest conclusively to an environment of low topographic relief and considerable tectonic stability [in the Western Interior], in sharp contrast to the situation in California and neighboring states, where distinguishable rock formations cannot be traced over any great distance, and the great sedimentary thicknesses, poor fossil content and subsequent tectonic complications combine to rule out fine stratigraphic analysis" (Hallam, 1975, p. 123).

Volcaniclastic sequences are, in fact, prime subjects for conducting refined stratigraphic and paleontologic studies. Because such strata characteristically display rapid lithofacies changes, a wide spectrum of onshore to offshore depositional environments and accompanying faunal trends may be traced along coeval strata over distances of just a few kilometers. These rocks also are typified by numerous tuff beds, and where tuff-bed sequences and ammonite successions can be interrelated, precise correlation is the rule. Detailed, stratigraphically based studies in such rocks, therefore, potentially are amenable to exceptionally refined basinal analysis. The Snowshoe Formation in the Suplee area is a case in point (Figures 1 and 2) (Taylor, 1977, 1981).

The study of the Snowshoe Formation reveals a full range of inferred intertidal to basinal paleocommunities (studied quantitatively by this author, 1981), which in their stratigraphic context provide the basis for a model of the shallow marine depth zonation. Comparison of the faunas from the Western Cordillera, Western Interior, and Europe demonstrates the applicability of the zonation over wide areas and in the disparate settings of the eugeosynclinal and epeiric environments. This suggests that the nearshore to offshore distributional pattern of the invertebrate fauna documented initially in Oregon provides a model of general significance for the Jurassic.

The zones may be recognized by characteristic, depth-related clusters of paleocommunities or by unique co-occurrences and relative abundances of taxa (Figures 3 and 4). Boucot (1975) applied the term "benthic assemblage" (= marine benthic life zone of Berry and Boucot, 1971, 1972) to groups of benthonic communities that are depth related. Boucot (1975) also suggested the use of parallel sets of planktonic assemblages where appropriate. To facilitate a holistic approach, the term "composite assemblage" is proposed here for depth-related faunal associations and combinations of taxa encompassing all preserved fauna. In the definition of the composite assemblage, emphasis is placed on the bathymetric overlap in diversity and abundance of higher (supra-familial) taxa and certain ecologic groups (e.g., benthonic, nektonic, and planktonic taxa), because these are expected to retain a relatively stable arrangement, both temporally and geographically.

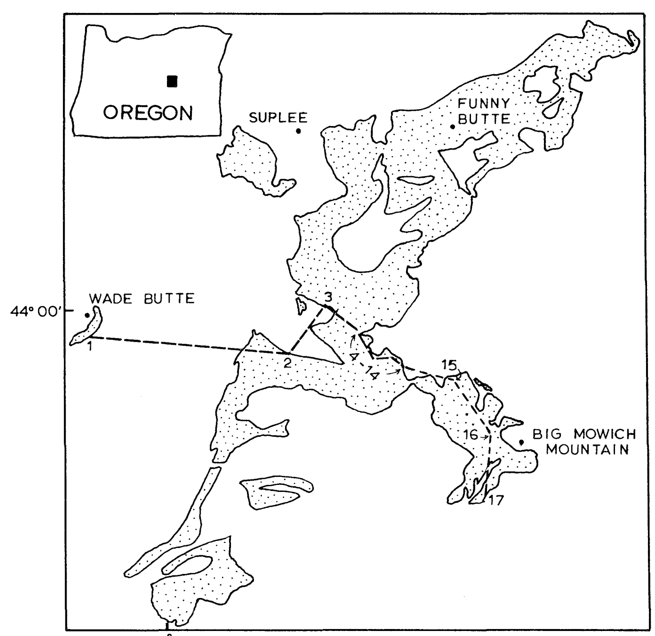

Figure 1. Location map showing distribution of Snowshoe Formation (stippled) in the Suplee area. Numbers along transect (dashed line) indicate locations of stratigraphic sections.

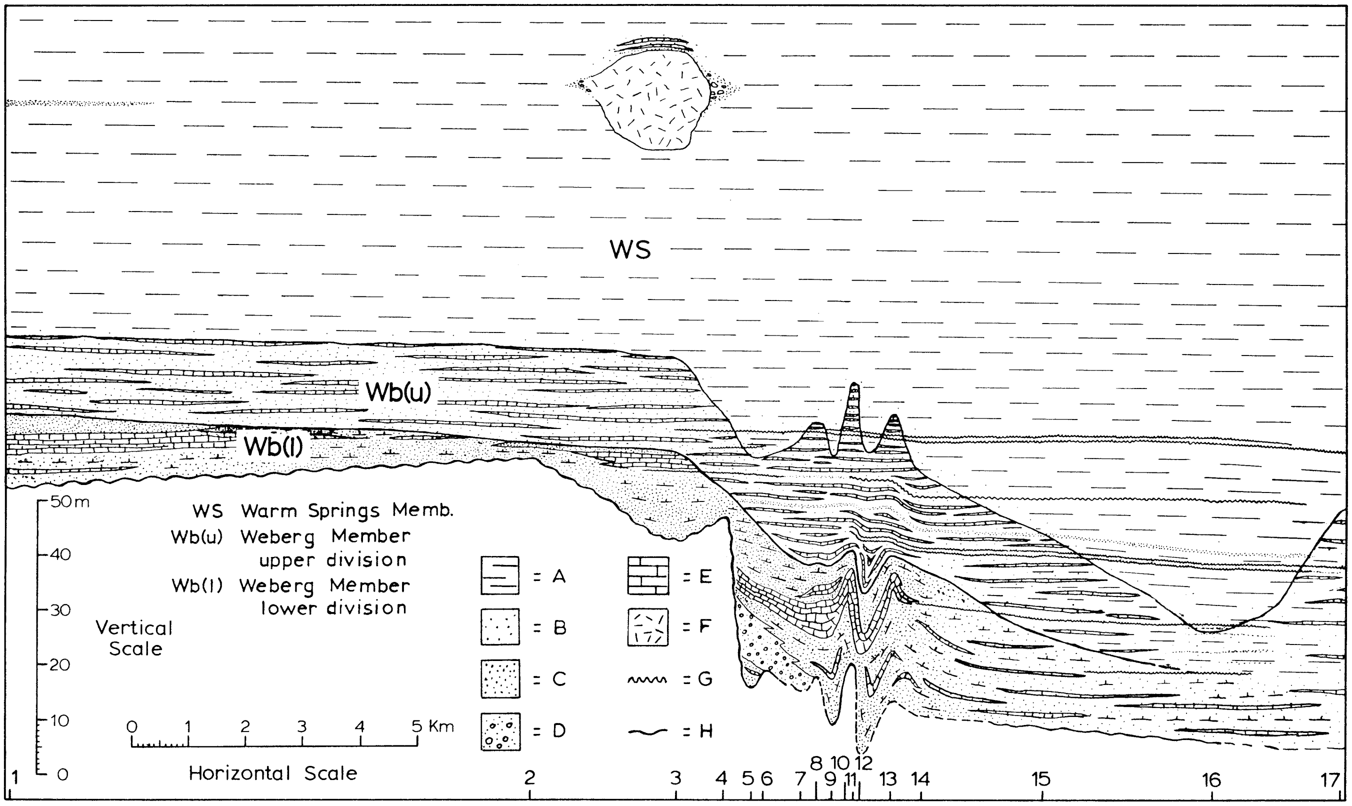

Figure 2. Cross section giving lithologies in the Snowshoe Formation in the Suplee area. Numbers at bottom indicate relative positions of stratigraphic sections, locations of which are shown in Figure 1. Lithologies are as follows: A = mudstone; B = coarse siltstone to very fine sandstone; C = fine to coarse sandstone; D = conglomerate; E = limestone; F = andesite; G = tuff bed; H = unconformity.

THE SNOWSHOE FORMATION

Stratigraphy

The Snowshoe Formation crops out extensively in the Suplee-Izee area (Dickinson and Vigrass, 1965) and is part of a thick Jurassic volcaniclastic sequence in the forearc-basin terrane of Brooks (1979). The formation in the Suplee area is entirely Middle Jurassic (Bajocian) in age and consists, in stratigraphic sequence from lowest to highest, of the Weberg Member (calcareous sandstone), Warm Springs Member (mudstone), and Basey Member (andesitic sandstone) (Dickinson and Vigrass, 1965). A stratigraphically higher member, the "Shaw" of Dickinson and Vigrass (1965), is now considered to be a westward extension of the Trowbridge Formation (Imlay, 1973, 1981; Smith, 1980). This study centers on the richly fossiliferous Weberg and Warm Springs Members.

Because the formation transgressed toward the west in the Suplee area, progressively offshore deposits can be traced upsection at any locality and from west to east (in the lower part of the section) along coeval strata (Figure 2). The nearshore-offshore trends and inferred hydrodynamic regimes are indicated by the (1) geometry of the basin, (2) sedimentary structures, (3) sedimentary textures, and (4) abundance of tuff beds. Inshore lithologies interpreted to have been deposited in a high-energy regime characteristically are coarse grained and lack tuff beds. (The tuff beds were destroyed by intensive current and/or wave activity.) Offshore lithologies deposited in quiet water are characterized by fine-grained texture, thin parallel lamination, and abundant thin tuff beds.

THE FAUNAL GRADIENT

There is an excellent representation of higher taxa in the Snowshoe Formation. The fauna is bivalve dominated, as is typical of the Jurassic. Other important groups include the diverse ammonites, locally abundant brachiopods, and volumetrically predominant crinoids. Figure 5 illustrates the life habits of various invertebrates that are discussed below. Before faunal trends are outlined, comments are necessary concerning ammonite distribution and the life habit of offshore bivalves.

Because ammonites and nautilids are externally shelled cephalopods with phragmocones that were gas-filled, the problem of post-mortem shell drift must be considered (Reyment, 1958; Chamberlin and others, 1981; both provide additional references). The distribution of ammonites in the

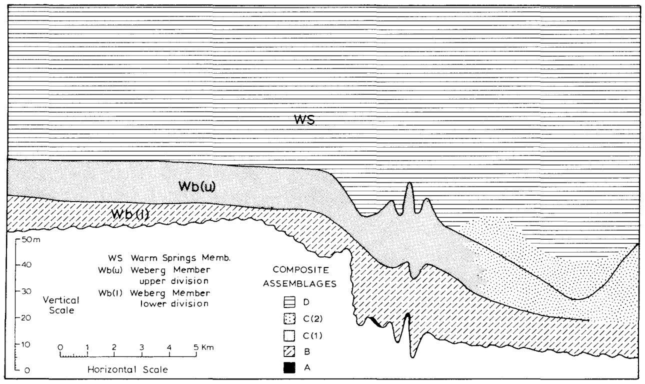

Figure 3. Cross section giving composite assemblages in the Snowshoe Formation. Composite Assemblage A represents the farthest inshore environment, while Assemblage D represents the basinal environment.

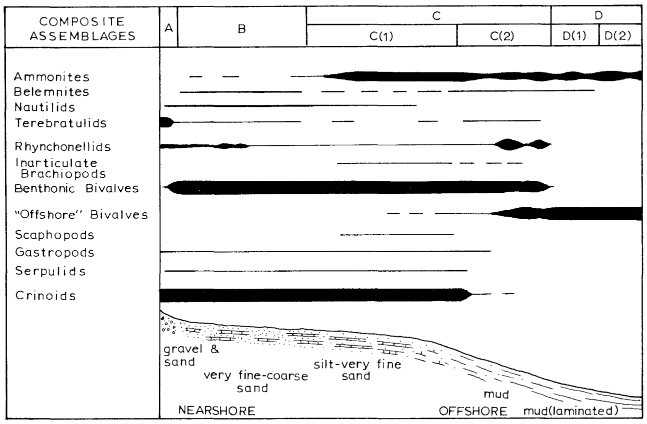

Figure 4. Schematic representation of the nearshore to offshore distribution and abundances of invertebrates in the Snowshoe Formation.

Snowshoe Formation suggests that post-mortem shell drift was an insignificant phenomenon. Ammonites are abundant only in a restricted environmental zone (Figure 6). They are rare in basal deposits, abundant in intermediate strata, and rare again in offshore deposits. This distributional pattern is not a preservational feature, because the ammonites found in areas where they are uncommon are reasonably well preserved. The transgressive nature of the belt of abundant ammonites demonstrates that it represents their habitat. If post-mortem shell drift were common, the shells would inevitably have been much more widely distributed in the inshore and offshore facies. Similar ammonite distributional patterns are characteristic of all of the Jurassic formations with which the author is familiar. It is clear that the ammonite distribution reflects their habitat and that the occurrence data are useful for analyzing the faunal bathymetric gradient. Ammonites apparently were unable to exploit the shallow-water, high-energy environment represented by the basal deposits of the Snowshoe Formation, as suggested, for example, by inferred musculature indicating poor swimming capabilities (Mutvei and Reyment, 1973; Kennedy and Cobban, 1976). While not enough nautilid (*Cenoceras*) specimens were collected to ascertain whether their distribution is that of their habitat, they are most common in the study area in facies inshore of ammonites. This inshore distribution may have occurred because the nautilids were better swimmers than the ammonites (Mutvei and Reyment, 1973).

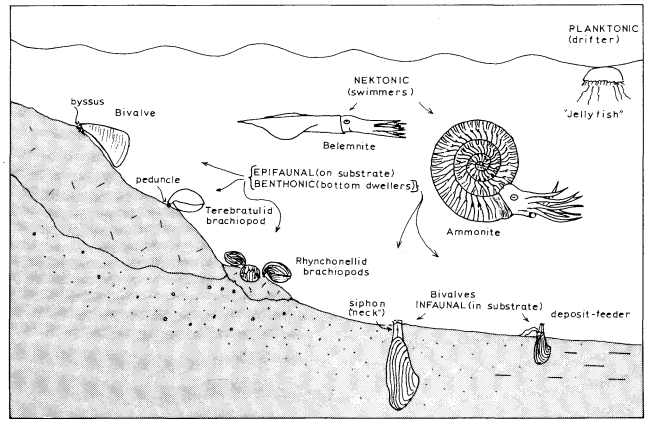

Figure 5. The life modes of certain Jurassic invertebrates, with an explanation of relevant terminology.

There is conjecture concerning the life habit of certain thin-shelled bivalves that occur typically in offshore argillaceous facies. *Bositra* is one such pelecypod which occurs in the Snowshoe Formation. The genus has been regarded variously to have had a planktonic or benthonic life habit (Jefferies and Minton, 1965; Kauffman, 1978). The decision was made to apply the noncommital term "offshore" bivalve to certain genera (*Bositra* and *Parainoceramus* in the Snowshoe Formation) having an offshore distribution in facies where there are few fossils proved to have been benthonic.

The sequence from nearshore to offshore of faunas, lithologies, and inferred depositional environments is described below (Figure 4).

Terebratulid brachiopods occur locally in the basal beds of the formation. Common associates are rhynchonellid brachiopods and bivalves that were capable of firm attachment to hard substrates. The associated lithologies are limestone and sandstone which commonly are pebbly. The inferred environment is one of extremely shallow water and high energy.

Farther offshore is a highly diverse fauna dominated by bivalves which along with the gastropods tend to be comparatively large and thick shelled. Terebratulids are uncommon, rhynchonellids are abundant locally, nautilids are rare but most common here, and ammonites usually are uncommon and not diverse. No "offshore" bivalves are present. The lithology typically is fine to coarse (commonly granule-bearing) sandstone and limestone. No tuff beds occur. The inferred environment is high-energy, as attested by the coarse-grained lithology and the absence of tuff beds.

The next fauna offshore is diverse and dominated by bivalves, most of which are small and weakly ornate. Most gastropods are small. Ammonites are abundant and diverse, articulate brachiopods are uncommon, and "offshore" bivalves are uncommon but do occur. The lithology is a very fine sandstone to coarse siltstone with numerous thin limestone interbeds. A few thicker (greater than 5 cm) tuff beds occur. The inferred environment is of lower energy than the previous one, but one in which current and/or wave activity were persistent.

The benthonic fauna becomes markedly less diverse farther offshore. Deposit-feeding bivalves are locally common, and "offshore" bivalves are abundant in places. Bivalves are small and weakly ornate. Rhynchonellids may be numerically dominant. The lithology is mudstone, which commonly is sandy. There are numerous thick tuff beds, but few thin ones.

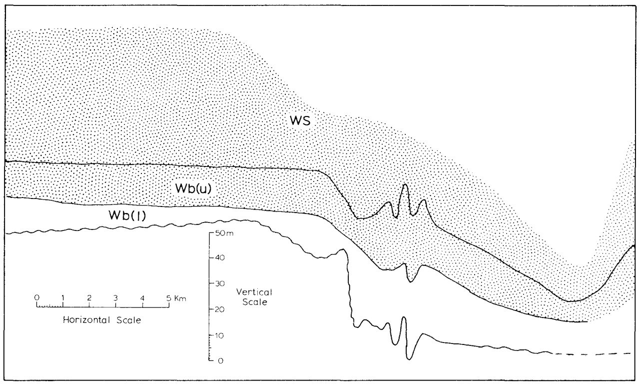

Figure 6. Zone of common ammonites (stippled) in the Snowshoe Formation. Wb(l) = Weberg Member, lower division; Wb(u) = Weberg Member, upper division; WS = Warm Springs Member.

The inferred environment is of somewhat lower energy than the previous one, as indicated by the finer rock texture and more common tuff beds.

The basinal environment yields abundant ammonites and "offshore" bivalves to the near exclusion of indisputed benthos. Ammonites are most diverse in the inshore part, where belemnites are restricted. The lithology is laminated mudstone with abundant thin beds and laminae of tuff. The inferred environment is one of very quiet water, as suggested by the fine-grained and parallel-laminated lithology and by the abundance of thin tuff beds.

Shelly macrofauna is rare farther offshore.

THE COMPOSITE ASSEMBLAGES

Three regions are considered in the following account of the composite assemblages. The first is the Western Cordillera of the United States (including Nevada), where the author has examined most of the stratal sequences. Assignments of the various faunas are based on field data and collections of the author, as well as on the literature. The formations from Oregon and northern California are eugeosynclinal, while those in Nevada (Sunrise Formation and marine part of Dunlap Formation) are epeiric.

The other two regions are the Western Interior of the United States and Europe. Both areas are dominated by epeiric deposits. The allocation to the composite assemblage sequence given below of faunas from the Western Interior is based primarily on the quantitative paleoecologic work of Wright (1973, 1974). Assignments of European faunas are restricted primarily to quantitatively based paleoecologic analyses (Duff, 1975; Fürsich, 1976a,b, 1977; Kauffman, 1978; Morris, 1979; Palmer, 1979) furnishing abundance data which permit allocations.

Composite Assemblage A

Characterization: This assemblage includes faunas from the intertidal to very shallow sublittoral, high-energy part of the gradient. Epifaunal (cemented, byssate, or pedunculate) taxa are numerically dominant where the substrate was hard. Brachiopods, particularly terebratulids, may be most abundant. Siphonate feeders such as *Tancredia* occur in sandstones. Species diversity is low.

Associated substrates: The faunas generally occur in coarse-grained lithologies.

Examples: Lower Jurassic faunas occurring in a position equivalent to this assemblage (or Assemblage B) in Oregon in the Robertson Formation include "reefs" and accumulations of the rudistlike bivalve *Plicatostylus* (= *Plicatostylus* "assemblage" of Batten and West, 1976) and the closely associated low-diversity fauna of *Nerinea*, commonly with terebratulids (= *Nerinea* "assemblage" of Batten and West, 1976). Similar Lower Jurassic faunas occur in California in the Thompson Limestone (Batten and Taylor, 1978), in Nevada locally near the top of the Sunrise Formation (Silberling, 1959; Smith, 1981), and in Oregon near the top of the Donovan Formation (Smith, 1981). Suggested intertidal environments in the Dunlap Formation (Toarcian?) in Nevada yield common rhynchonellid brachiopods and inferred algal mat or stromatolite structures (Stanley, 1971). Another Lower Jurassic occurrence is in the lower part of the Graylock Formation in Oregon, from "massive," algae-rich bioherms up to 23 m thick.

In the Western Interior the assemblage is represented in the Upper Jurassic by the *Tancredia transversa* association (Wright, 1974). In Europe the assemblage is not well documented by quantitative paleoecologic work. Terebratulids, nonetheless, are common locally in very shallow-water, high-energy environments (Ager, 1965).

Composite Assemblage B

Characterization: This assemblage yields diverse and mostly bivalve-dominated paleocommunities. All bivalve life-habit groups except perhaps infaunal deposit feeders are well represented in terms of species diversity and numbers of individuals. Overall, the bivalve and gastropod faunas from this assemblage are characterized by relatively large, ornate, thick-shelled taxa. Ammonites usually are uncommon, and "offshore" bivalves are not present.

Associated lithologies: Lithologies in the Western Cordillera are fine- to coarse-grained sandstone and sandy limestone sequences. Lithologies in the Western Interior typically are siltstones and sandstones and similarly textured limestones. In Europe, the lithologies consist of variously textured limestones, sandy shales, marls, limestones, and other lithologies (see Hallam, 1975, under "nearshore marine associations").

Examples: Lower Jurassic faunas attributed to this assemblage in the Western Cordillera are from (1) Oregon, from the Robertson Formation (Batten and West, 1976, *Modiolus* and infaunal "assemblages"), the Suplee Formation (Dickinson and Vigrass, 1965; Hallam, 1965; Smith, 1981), and the upper part of the Donovan Formation from a red sandstone (Smith, 1981); (2) California, from the Hardgrave Sandstone (Hyatt, 1892; Hallam, 1965); and (3) Nevada, from the Sunrise Formation (upper part of unit 5 and lower part of 6 of Muller and Ferguson, 1939, distinctive fauna includes *Weyla*, *Cardinia*, *Gresslya*, *Pholadomya*, large gastropods; and unit 8 of Muller and Ferguson, 1939, see Smith, 1981, for fauna). Included are Middle Jurassic faunas from California from sandy parts of the Potem Formation and Mormon Sandstone (Crickmay, 1933; Sanborn, 1960; Taylor, 1981).

In the Western Interior, paleocommunities that have primarily an inshore distribution include the Middle Jurassic *Trigonia americana*, *Meleagrinella curta*, and the *Pleuromya subcompressa* associations (Wright, 1974).

Most of the faunas described by Fürsich (1976a,b; 1977) from the Corallian of England and France are shallow-water ones, which may be assigned to this assemblage. The faunas described by Palmer (1979) from the Bathonian Hampen Marly and White Limestone Formations occur no farther offshore than this assemblage.

Composite Assemblage C

Characterization: This assemblage represents the lateral overlap of benthonic shelly faunas with diverse and abundant ammonites and/or "offshore" bivalves and is subdivided as follows: The faunas of Assemblage C(1) are primarily bivalve-dominated. Most bivalves and gastropods from this assemblage (and farther offshore assemblages) are smaller, less strongly ornate, and thinner shelled than those from Assemblage B. Brachiopods are uncommon (in United States at least). Ammonites are common and diverse. "Offshore" bivalves occur in the assemblage but are more common in assemblages representative of greater distance from shore. Composite Assemblage C(2) consists of benthonic faunas which commonly are dominated either by bivalves or rhynchonellids (in Western Cordillera). Deposit-feeding bivalves are well represented. "Offshore" bivalves occur sporadically but may be abundant. Ammonites are abundant locally. Noncephalopod diversity is moderate to low.

Associated lithologies: Rocks in the Western Cordillera associated with Assemblage C(1) usually are very fine sandstone to coarse siltstone sequences with numerous limestone beds. In the Western Interior, they are clays, with minor siltstone, fine sandstone, and thin limestone beds. In Europe, they commonly are nonlaminated clays and marls. Lithologies from the Western Cordillera commonly associated with Assemblage C(2) are sandy mudstones; in Europe, the lithologies are clays, shales, and mudstones that often are laminated.

Examples: Lower Jurassic occurrences in the Western Cordillera include Assemblage C(1) in the Sunrise Formation (lower part of unit 5 of Muller and Ferguson, 1939), Assemblage C(2) locally in the Suplee-Nicely formational transition, and Assemblage C(undifferentiated) in the Sunrise Formation in the upper part of unit 6 of Muller and Ferguson (1939). Assemblage C(2) occurs in the Middle Jurassic in the Mormon Sandstone (Taylor, 1981).

In the Western Interior Middle and Upper Jurassic, the *Gryphaea nebrascensis* (Upper Jurassic occurrence in "Upper Sundance Formation," personal observation) and *Camptonectes bellistriatus* associations have a paleogeographic position no farther offshore than that of Assemblage C.

In Europe, the most offshore associations from the Corallian as described by Fürsich (1976a,b; 1977), which typically occur in fine-textured lithologies, probably occur in a position no farther offshore than that of Assemblage C(1). Typical are the *Lopha gregaria* and *Oyster/Isognomon promytiloides* associations. Composite Assemblage C(2) is well represented in the lower Oxford Clay (Duff, 1975) and the Toarcian "restricted shale facies" at Yorkshire (Morris, 1979).

Composite Assemblage D

Characterization: This assemblage represents the occurrences of ammonites, nautilids, belemnites, and "offshore" bivalves over parts of the shelf that were offshore from those where indisputed shelly benthonic faunas thrived. The assemblage is divided tentatively as follows: Assemblage D(1) includes abundant and diverse ammonites. The dominant bivalve group is "offshore." Assemblage D(2) has ammonites and/or "offshore" bivalves, to the near exclusion of other taxa including belemnites, at least in the Middle Jurassic formations in the Western Cordillera. In eugeosynclinal regions of western North America, farther offshore areas only rarely furnish shelled macroinvertebrates.

Associated lithologies: Lithologies in the Western Cordillera primarily are laminated mudstones and, less commonly, sandy mudstones. The lithologies in Europe typically are laminated mudrocks or clays, which commonly are bituminous.

Examples: In the Western Cordillera, Lower Jurassic examples are from (1) Oregon, from the Hurwall Formation (Smith, 1981); (2) California, from the Sailor Canyon Formation (Imlay, 1967); and (3) Nevada, from parts of the Sunrise Formation (lower part of unit 7 and "black shales" in unit 9 of Muller and Ferguson, 1939).

No faunas from the Western Interior are referable to this assemblage. In Europe, the assemblage is documented where indisputed benthonic taxa are scarce in the Toarcian Posidonienschiefer (Kauffman, 1978) and in the coeval bituminous shale at Yorkshire (Morris, 1979).

DEPTH OF FAUNAS

The shelly faunas from the Snowshoe Formation thrived in shallow water. The short distances from inshore faunas to coeval basinal ones in the Snowshoe Formation (Figure 3) attest to the shallow-water environment (at most, just tens of meters deep) in which the benthonic shelly faunas lived. The depth limit of the "offshore" bivalves and ammonites is less certain. Shallow-water conditions are suggested in the Warm Springs Member, however, where an approximately 20-m-thick andesite flow is capped by about 3 m of shallow-water limestone beds containing sand- to pebble-size siliclastic detritus (Figure 2). The inferred shallow-water environment is consistent with suggested depth limits of perhaps 50-100 m (Hallam, 1975) for abundant and diverse benthonic shelly faunas (= Assemblages A-C) of this report.

COMPARISON WITH EUROPEAN BIVALVE "ECOLOGIC ASSOCIATIONS"

Hallam (1976) provided an account primarily of bivalve distribution in Europe by describing "ecologic associations." His "reefal" and "nearshore marine associations" have a paleogeographic position no farther offshore than that of Assemblage B, as indicated by numerous ornate and large bivalve genera and generally depauperate ammonite faunas. Paucity of ammonites and stratigraphic context suggest a similar shallow-water environment for the "lagoonal associations." His "marine basinal associations" are referable to farther offshore composite assemblages. The two divisions of the "marine basinal associations," termed "laminated bituminous shales" (faunas referable to Assemblages C(2) and D) and "nonbituminous bioturbated clay or marl" (faunas referable to composite assemblages no farther offshore than C(1)), are allocated to the composite assemblage sequence by the overall smaller size of bivalve individuals and by common "offshore" bivalves (in bituminous shales only) and ammonites. Hallam (1967a,b; 1975) at first misinterpreted the depth relationships of the bituminous shales and bioturbated clays and marls but later conceded the more basinal position of the bituminous facies (Hallam, 1978). While the account of the European "ecologic associations" is generalized, it nevertheless is consistent with the findings reported here.

CONCLUSIONS

The data indicate that (1) the depth zones documented stratigraphically for the Snowshoe Formation are applicable over a wide geographic area and to the epeiric as well as the eugeosynclinal suites, and (2) they provide a model of general significance for the Jurassic.

The model, being comprehensive, emphasizes the paleobathymetric distribution of the major invertebrate groups. The ammonites constitute one of the most diverse and abundant of these groups. The data from the Snowshoe Formation provide the most unequivocal evidence to date bearing on the problem of the importance of post-mortem drift of ammonite shells. The ammonites have a distributional pattern that clearly represents their habitat and, therefore, provides valuable information for the depth zonation.

The model manifests clearly the relative depths of the Jurassic seas over the three regions examined. As was to be expected, the eugeosynclinal Western Cordilleran region was deepest overall, as indicated by the thick mudstone sections containing only the most offshore faunas. Generally shallow-water conditions are indicated for northwest Europe, where facies such as the bituminous laminated shales (yielding offshore faunas) are developed rather sporadically (Hallam, 1978). Extremely shallow and/or restricted marine environments are indicated for the Western Interior by the documentation only of the inshore assemblages (A-C).

The model is expected to be a powerful tool for interpreting the basinal history of the Oregon Jurassic. Such study is certainly in order as an aid for deciphering the complex story that is unfolding concerning the tectonic collage which characterizes much of the Western Cordillera (Coney and others, 1980).

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"I'm Pterry, this is Ptom and this is Ptessa."

USGS publishes book on 1980 eruptions of Mount St. Helens

A report that summarizes the 1980 eruptions of Mount St. Helens in southwest Washington and the initial results of wide-ranging scientific studies of the volcanic activity and eruptive products has been published by the U.S. Geological Survey (USGS). The hard-bound, 844-page volume was designed and edited to be of interest to, and understandable by, a general audience as well as scientists. The 2-in.-thick book is extensively illustrated with maps, charts, and pictures, many of them in color.

It contains more than 60 separate articles by various authors mainly from the USGS but some from other government agencies, universities, and industry. The articles range from such technical subjects as "Petrography and particle-size distribution of pyroclastic-flow, ash-cloud and surge deposits" to more easily understood items such as a summary of eyewitness accounts and a description of "Growth of lava domes in the crater, June 1980-January 1981."

Editors of the book are Peter W. Lipman and Donal R. Mullineaux, both USGS geologists in Denver, Colo., who were members of the USGS monitoring and hazard-assessment team in the early weeks of the 1980 eruptive activity. Mullineaux and Dwight R. Crandell were the authors of a USGS report published in 1978 in which they predicted, based on their almost 20 years of study of Mount St. Helens, that the volcano would erupt again, probably explosively as it did May 18, 1980, and possibly before the end of the century. Crandell also was a member of the USGS Mount St. Helens team in 1980 but has since retired and works part time for the USGS.

USGS Director Dallas L. Peck said that the descriptions by Crandell and Mullineaux and their locations of potential hazards associated with possible eruptions of Mount St. Helens—such as pyroclastic flows, mudflows and flooding—proved accurate, with few exceptions, in the 1980 eruptions. "The volcanic-hazards assessment by Crandell and Mullineaux provided a key element in reducing hazards to life and property," Peck said.

The magnitude of the landslide and lateral blast on the north side of the volcano May 18, however, was unprecedented at Mount St. Helens and unexpected, said Mullineaux, Crandell, and C. Dan Miller, another USGS geologist in Denver, in their article in the book. The lateral blast extended about three times farther from the volcano than the largest known previous blast at Mount St. Helens, and it devastated an area that probably is 10 to 15 times larger. "The May 18 eruption of Mount St. Helens showed that catastrophic events can exceed any known precedent at a given volcano," the geologists said.

The book, titled *The 1980 Eruptions of Mount St. Helens, Washington*, was published as USGS Professional Paper 1250. Copies can be purchased, for $35 each, from the Branch of Distribution, U.S. Geological Survey, 604 South Pickett St., Alexandria, Va. 22304. Orders must include the identification number (PP-1250) and checks or money orders payable to the U.S. Geological Survey. □

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A revision to the estimate of the geothermal potential of Newberry Volcano

In the April 1982 issue of *Oregon Geology* (p. 44-46), the Na/Li geothermometer was used to estimate reservoir temperatures of 335°C, 375°C, and 370°C for East Lake Hot Springs, Paulina Hot Springs, and the Little Crater Campground warm well, respectively. These temperatures are, in fact, absolute temperatures (°K), and the correct estimates of reservoir temperature (based on the Na/Li geothermometer) are 62°C, 102°C, and 97°C. These results indicate that the Na/Li geothermometer is no better than the others for estimating reservoir temperatures based on the chemistry of the fumarolic springs at Newberry Volcano. Thus, while it is still quite possible that the reservoir temperatures at Newberry exceed 300°C, there is no firm basis for making such an estimate. All that can be said with certainty regarding the temperatures at Newberry is that a temperature of 265°C exists at a depth of 930 m in the USGS drill hole inside the caldera.

In light of the above information, a revision of Table 1 is in order.

Source of calculation	Reservoir volume (km^3)	Reservoir temperature (°C)	Reservoir thermal energy (10^{18}J)	Electrical (MWe for 30 years)
USGS Circ. 790[1]	47±16	230±20	27±10	740
DOGAMI[2]	47	265	32	1,116
DOGAMI[3]	66	265	45	1,563
DOGAMI[4]	569	265	388	13,430

[1] Brook and others, 1979, p. 54.

[2] Oregon Department of Geology and Mineral Industries (DOGAMI) calculation, using reservoir volume estimate of Brook and others (1979) and new temperature data from Newberry 2 test well.

[3] DOGAMI calculation using increases in both reservoir temperature and volume from Newberry 2 hole (Sammel, 1981).

[4] DOGAMI calculation using volume estimate based on gravity work of Williams and Finn (1981).

It should be noted that while the above results are probably conservative with respect to temperature (the reservoir temperature should increase with depth), they are decidedly *not* conservative with respect to reservoir volume. In cases 3 and 4, the *maximum* possible reservoir volume has been used in making the estimates. Since reservoir volume controls the size of the energy estimates to a larger extent than does the reservoir temperature, the estimates must be considered highly optimistic overall.

—*Gerald L. Black, Oregon Department of Geology and Mineral Industries* □

Student AIME chapter forms at PSU

By vote of the Board of Directors of the Society of Mining Engineers of the American Institute of Mining, Metallurgical, and Petroleum Engineers (SEM-AIME) on February 15, 1982, official status was awarded to the newly formed Portland State University Student Chapter.

Officers of the group are Tom Bessler, President; Roger Congdon, Vice President; and Carolyn Browne, Secretary-Treasurer. Faculty Advisor is Michael L. Cummings, Earth Sciences Department, Portland State University; Section Counselor is Beverly F. Vogt, Oregon Department of Geology and Mineral Industries. □

USGS lists early signs of possible landslides

On March 1, 1982, the U.S. Geological Survey (USGS) issued a press release regarding accelerated landslide activity in northern California during the past, extremely rainy winter season. Parts of that release are applicable to Oregon as well and are reproduced below:

"Large, deep slides can occur on weakened zones as much as several hundred feet below the ground surface and may be tens, hundreds, or even thousands of feet across. Rain water that seeps into the ground continues to migrate through tiny openings in the rocks to the water table. Additional water infiltrating the soil and reaching the saturated zone causes the water table to rise. This causes increased water pressures in the ground and reduces soil strength, particularly along previous fractures, and can trigger slides in slopes that had been stable during long dry periods. Old landslides may be reactivated, and new ones may form. The underground water continues to migrate long after the storms cease and can trigger additional landslides.

"The time and duration of landslide movement may vary widely—some slides may begin to move during a heavy storm; others may not move noticeably until weeks or months later when the rainwater has infiltrated to greater depths. The rates of landslide movement commonly are a few inches to a few feet per day but can be very rapid.

"Although higher rainfall has been recorded in the past, the higher rates preceded most of the large-scale urban development of the hillsides [in California]. Development has, in some places, occurred on old landslides, and in many places construction activities have resulted in the undercutting and steepening of slopes or the addition of weight to slopes in the form of fill and new structures, without, at times, adequate provisions for surface- and ground-water drainage or buttressing of unstable ground.

"The danger of landslide damage is expected to be greatly lessened in areas where grading ordinances, building regulations, and geologic and engineering advice have been available and complied with in the development of hillside areas. The present saturated conditions, however, will provide a severe test of the precautions that have been taken by local communities.

"Residents of buildings on or near steep slopes should, for their own safety, be particularly alert if new rainstorms bring additional heavy rainfall in the near future. Although debris flows move rapidly, most of them are small and can be avoided.

"As the rainy season continues, and for some time after, residents should also be alert to the early signs of possible impending damage from other, deeper-seated landslides. Such signs may include any one or more of the following:

- doors or windows that stick or jam for the first time;
- new cracks in plaster, tile, brickwork, or foundations;
- outside walls, walks, or stairs pulling away from the building;
- slowly developing and widening cracks in the ground or paved areas;
- breakage of underground utility lines;
- leakage from swimming pools;
- movement or tilting of fences, retaining walls, utility poles or trees; and
- new water seeps or bulging ground at base of slopes." □

MEETING ANNOUNCEMENTS

GSOC luncheon meetings

The Geological Society of the Oregon Country (GSOC) holds noon meetings in the Standard Plaza Building, 1100 SW Sixth Avenue, Portland, in Room A adjacent to the third floor cafeteria. Topics of upcoming meetings and speakers include:

May 21—*Forty Floods*: by John Eliot Allen, Emeritus Professor of Geology, Portland State University.

June 4—*Waterways and Geology*: by James Seeley White, Personnel Manager, Oregon Department of Fish and Wildlife.

June 18—*A Nonexplosive Demolition Agent*: by John Hood, Engineering Geologist, Con-Rock Company.

Hydrotech Club luncheon meeting

The Hydrotech Club of Portland, founded in 1955 to promote interest in water, meets the fourth Friday of each month. Reservations are required and should be made by Thursday prior to the meeting by phoning 229-5683. The luncheon costs $5 and is at the Jasmine Tree Restaurant, 401 SW Harrison St., Portland. Parking is validated for the lot at 5th and Harrison. An alternative way to get to the meeting is to take bus 41, 42, 43, 44, or 45 from downtown.

May 28—*Inland Navigation in Oregon and Interstate Waters*: by Jack Stappler, Tidewater Barge Lines. □

Brownfield enters private sector

Michael E. Brownfield, Research Geologist with the Oregon Department of Geology and Mineral Industries since August 1980, has resigned his position to become Senior Coal Geologist with Consolidation Coal Company in Denver.

Brownfield's responsibilities with the Department included geologic mapping and coordination of efforts with university and federal geologists as part of the joint State—U.S. Geological Survey's revision of the geologic map of Oregon. He also coordinated collection of data from western Oregon and western Washington for the Correlation of Stratigraphic Units of North America (COSUNA) project, for which he also developed two generalized stratigraphic columns.

During his tenure with the Department, Brownfield wrote an article on coal in Oregon for *Oregon Geology* (v. 43, no. 5) and completed several mapping projects. He and co-author Herb Schlicker produced two open-file maps of the Amity and Mission Bottom quadrangles (0-81-5) and the McMinnville and Dayton quadrangles (0-81-6). Soon to be released as part of the Department's Geological Map Series are Brownfield's geologic maps of the Sheridan (GMS-23) and Grand Ronde (GMS-24) quadrangles. His work in these quadrangles has further clarified the stratigraphy of this part of the Oregon Coast Range, an area of widely variable interpretations in the past. His open-file maps of the Ballston (0-82-2) and Langlois (0-82-3) quadrangles will be released later this year. □

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