43116-E2-PP-01M

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

PETROLEUM POTENTIAL OF WILDERNESS LANDS, IDAHO

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MISCELLANEOUS INVESTIGATIONS SERIES
Published by the U.S. Geological Survey, 1983

Petroleum Potential of Wilderness Lands in Idaho

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PETROLEUM POTENTIAL OF WILDERNESS LANDS IN THE WESTERN UNITED STATES

GEOLOGICAL SURVEY CIRCULAR 902-F

This chapter on the petroleum geology and resource potential of Wilderness Lands in Idaho is also provided as an accompanying pamphlet for Miscellaneous Investigations Series Map I-1540

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ABSTRACT

Idaho Wilderness Lands having oil and gas potential were grouped into seven clusters. Of these, two clusters, with potentials many times greater than those of the other clusters, are situated in the Overthrust belt of southeastern Idaho. They are discussed in detail in a separate chapter on the Wyoming-Utah-Idaho thrust belt. Of the remaining five clusters, situated in widely separated and geologically distinct areas of the State, two have low to zero potential, two have low potential, and one has medium potential. Because of scarcity of analogs due to lack of production data, these five clusters are evaluated mainly according to the presence, type, and maturation of possible petroleum source rocks. All tracts outside these clusters are considered to have zero potential, except for one tract, formed by the westernmost part of Yellowstone National Park, which has an unknown potential.

INTRODUCTION

Idaho Wilderness Lands, which comprise 53 tracts totaling a little more than 2 million acres, are grouped into seven clusters. A single tract of 36.7 thousand acres with unknown potential comprises a narrow strip of easternmost Idaho within Yellowstone National Park (fig. 1). With this exception, all wilderness tracts lying outside the clusters are considered to have zero petroleum potential. The geology of clusters 6 and 7, which contain three tracts totaling 149,389 acres, is discussed separately and in more detail under the Wyoming-Utah-Idaho thrust belt (Powers, chapter N in this circular). The remaining five clusters lie in geologically distinct frontier provinces. Cluster 1, situated in the panhandle of northern Idaho, has mainly Late Precambrian metasedimentary rocks at the surface. Such terrane ordinarily would be considered to lack petroleum potential, but here the Precambrian rocks occupy nearly horizontal thrust plates that may be underlain by Paleozoic sedimentary rocks at depth. Cluster 2 is underlain by gently dipping Paleozoic sedimentary rocks between the Centennial Range and Yellowstone National Park. Cluster 3, lying east of the Idaho batholith and north of the Snake River volcanic plain, comprises mainly mountain ranges composed of complexly folded and faulted rocks. Cluster 4, situated in the southwest corner of the State, is underlain by sedimentary rocks of the Tertiary Lake Bruneau basin. These rocks are capped by an extensive cover of younger Tertiary volcanic rocks. Cluster 5 is underlain by Paleozoic sedimentary rocks along the crest of the Bear River and Portneuf Ranges at the eastern edge of the Eastern Basin and Range province.

GEOLOGIC FRAMEWORK

To help relate the seven clusters that are evaluated herein to their geologic settings, a geologic map of Idaho (Bond, 1978) is available at a scale of 1:500,000. This scale is twice as large as the 1:1,000,000 scale of the Miscellaneous Investigations Series Map I–1540 (in press) showing the color-coded qualitative petroleum evaluation of Idaho's Wilderness Lands. The locations of the leading edges of two major thrust fault systems that disrupt geologic outcrop patterns and the offset of these thrust systems by a Paleozoic strike-slip fault, postulated by Poole and Sandberg (1977) and Sandberg and Poole (1977), are shown on figure 1. A detailed tectonic map by Blackstone (1980) shows the complex pattern of thrust faults and the oil and gas development in the Overthrust belt of southeastern Idaho. Distribution, thickness, and correlation of Devonian and Silurian rocks are shown by Poole, Sandberg, and Boucot (1977) and Sandberg and Poole (1977), and of Mississippian rocks by Poole and Sandberg (1977) and Gutschick, Sandberg, and Sando (1980). A correlation chart (Isaacson and others, 1983) shows the age, thickness, and nomenclature of Paleozoic and Mesozoic rocks in mountain ranges throughout Idaho.

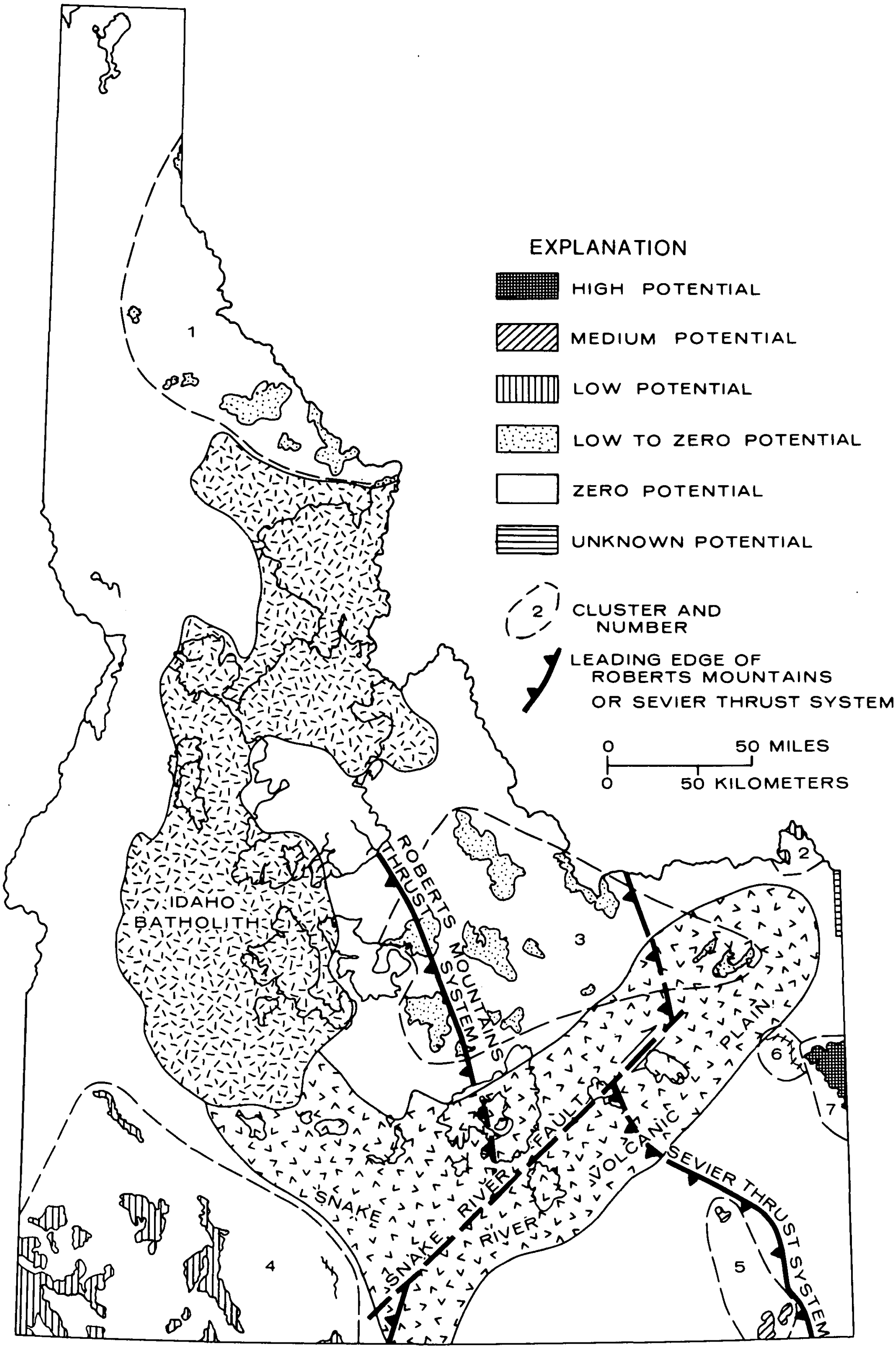

FIGURE 1.—Index map of Idaho showing outlines of Wilderness Lands, designated wilderness clusters, and their petroleum potential; location of Idaho batholith and Snake River volcanic plain; leading edges of Sevier and Roberts Mountains thrust systems; and postulated Snake River strike-slip fault (Poole and Sandberg, 1977; Sandberg and Poole, 1977).

PETROLEUM GEOLOGY

The petroleum resource appraisal of Wilderness Lands in Idaho, outside the Overthrust belt, is dependent on the four major parameters that govern accumulation—the presence of source rocks, maturation history, reservoir rocks, and traps. Because of the complex shuffling of many different rock types by several types of faulting, reservoir rocks and traps are considered to be broadly distributed. The types of structural traps and the ages and types of reservoirs encountered in the folded leading edges of thrust plates in that part of Idaho situated in the Wyoming-Utah-Idaho thrust belt are discussed in greater detail in this circular in chapter N by R. B. Powers. Possible Mississippian reservoir rocks and stratigraphic traps that extend from the Overthrust belt westward in southeastern Idaho were discussed by Sando, Sandberg, and Gutschick (1981). Consequently, the prime parameter devolves to the presence or absence of source rocks and their maturation.

SOURCE ROCKS

Published discussions of source rocks deal mainly with the eastern part of the State. Mississippian source rocks and the problems inherent in making evaluations based on outcrop samples were discussed by Sandberg, Grogan, and Clisham (1979). Organic carbon in shale beds of the Permian Phosphoria Formation was treated by Maughan (1975). Source beds in the Jurassic Twin Creek Limestone were evaluated by Swetland, Patterson, and Claypool (1978). Elsewhere in Idaho, the argillaceous and once organic-rich (but now thermally postmature) Devonian Milligen Formation, which previously had been considered Mississippian, is present in the Wood River area of central Idaho (Sandberg and others, 1975). In east-central Idaho, once organic-rich (but now thermally postmature) source beds are present in the flysch sequence of the Mississippian McGowan Creek Formation and in the Devonian, lower part of the Sappington Member of the Three Forks Formation (Sandberg, 1975). In southwestern Idaho, Tertiary lacustrine beds described by McDonald (1973) and Warner (1977, 1980) also apparently contain source rocks. Thus, source rocks capable of generating hydrocarbons have been documented in the areas of clusters 2, 3, 4, and 5.

MATURATION

Because of the widespread availability of source rocks, the next important consideration is their maturation. Maturation can be approximately determined from the study of ancient and present geothermal temperatures, which affect not only the ability of source rocks to generate hydrocarbons but also the preservation of oil and gas that has already migrated from them into reservoir rocks. A general indication of geothermal temperatures, although not the precise degree of maturation, commonly can be obtained from geothermal maps. Unfortunately, geothermal-gradient and subsurface-temperature maps of North America (American Association of Petroleum Geologists and U.S. Geological Survey, 1976a, 1976b) do not interpret much of Idaho except for the southeast corner and the west-central edge along the Snake River. More precise measurements of maturation are made from studies of microfossils contained in source rocks or rocks interbedded with source rocks. In Tertiary rocks, such as those in southwestern Idaho (cluster 4), maturation can be measured by study of temperature-induced color changes in contained spores and pollen. Elsewhere in Idaho, possible source rocks are all of Paleozoic age, so an important key to determining their maturation is the examination of conodonts, a unique group of microfossils. Conodonts are the fossilized toothlike, phosphatic hard parts of soft-bodied organisms that lived in most marine environments during Paleozoic and Triassic times but are now extinct. They serve as virtual geothermometers that readily indicate by their temperature-induced color changes or conodont color-alteration index (CAI) values on a scale of 1 (cold) to 8 (hot) the maximum temperature to which containing rocks have been subjected. The CAI scale was developed by Epstein, Epstein, and Harris (1977). The utility of conodonts to petroleum exploration in Idaho and adjacent States has been discussed by Sandberg and Poole (1977), Sandberg (1980), and Sweet and others (1981). A symposium volume edited by Sandberg and Clark (1979) presents conodont zonations and distributions on a systemic basis for Idaho and adjacent States. Maps by Harris and others (1980) and Sando, Sandberg, and Gutschick (1981) provide CAI values that are useful in evaluating the maturation of source rocks in Idaho. A more complete discussion of CAI values and other economically significant uses of conodonts is given in this circular, chapter H, in a companion paper on Nevada by C. A. Sandberg.

EVALUATION OF WILDERNESS LANDS BY CLUSTERS

Idaho wilderness tracts in the five clusters that are evaluated herein are situated mainly in two petroleum provinces that were used by Dolton and others (1981) for convenience in making resource appraisals of the entire United States. The tracts are here evaluated or ranked with respect to the total evaluation of their respective petroleum provinces. Clusters 1, 2, 3, and 4 lie in the Idaho-Snake River Downwarp province of Dolton and others (1981), except that one tract in cluster 3 extends eastward slightly into the south end of their Montana Overthrust Belt province, which barely enters Idaho. Cluster 5 is bisected by the boundary between the Eastern Basin and Range province and the Wyoming-Utah-Idaho Overthrust Belt province. Because this arbitrary province boundary is a county line that follows the crest of the Bear River and Portneuf Ranges and the geologic setting is identical on either side, the entire cluster is evaluated as if it were in the Eastern Basin and Range province. Clusters 6 and 7 lie in the part of the Wyoming-Utah-Idaho Overthrust Belt province that barely enters the southeastern part of Idaho from Wyoming; they are evaluated in independent treatment of that province in chapter N in this circular by R. B. Powers and their evaluations are briefly summarized here.

Cluster 1.—Very little is known about the Paleozoic sedimentary rocks that are believed to underlie the nearly horizontal thrust plates of Late Precambrian metasedimentary rocks in the panhandle of Idaho (fig. 1). However, the petroleum industry currently is exhibiting great interest in exploring the adjacent part of northwestern Montana. Moreover, a rock sample was recently collected by W. J. Perry, Jr., from near Roosville Custom Station, Montana, just south of the Canadian border and 48 miles (77 km) east of the northeast corner of Idaho, and submitted to me. This sample yielded conodonts that I interpret to have come from the Upper Devonian Palliser Formation and to have CAI values of 2 to 3. This range of CAI values indicates optimum maturation of hydrocarbons for oil and gas generation. The identification suggests that if Paleozoic rocks do extend beneath the Idaho panhandle, they would belong to a sequence similar to that of the Canadian Rocky Mountains. The rocks from which the Montana sample came are on a downthrown block, however, and may not be representative of rocks in the lower plate in Idaho (W. J. Perry, Jr., written commun., June 1983). Therefore, this frontier-province cluster, instead of being arbitrarily disregarded, is evaluated to have a low to zero potential. However, any results of nearby drilling might eliminate or substantially increase this evaluation.

Cluster 2.—This cluster lies at the east end of the Centennial Range and near Targhee Peak to the east. Conodont CAI values of 1.5 to 2 indicate optimum maturation of hydrocarbons for oil and gas generation in this area. However, because of a lack of favorable results from nearby drilling activity in southwestern Montana, the cluster is evaluated to have only a low potential.

Cluster 3.—This large cluster occupies, from east to west, parts of the Boulder Mountains, Pioneer Mountains, White Knob Mountains, Lost River Range, Lemhi Range, Beaverhead Mountains, and Snake River volcanic plain. Hundreds of samples, personally collected from Ordovician, Silurian, Devonian, Mississippian, and Pennsylvanian rocks of this area, have almost universal conodont CAI values of 5, an indication of pervasive thermal degradation of hydrocarbons. However, the cluster contains extremely thick sequences of Devonian source rocks (Sandberg and others, 1975) and Mississippian source rocks (Sandberg, 1975). Some of these conceivably might be found to be less heated in isolated windows at the surface or in thrust plates at depth. Because of the richness of these potential source rocks and because of the similar geologic setting to that of the Eastern Basin and Range province between the Roberts Mountains and Sevier thrust systems in Nevada, discussed in this circular by C. A. Sandberg, the cluster cannot be arbitrarily disregarded. It is here evaluated to have a low to zero potential. This rating could be reduced or substantially increased, depending on the results of any future drilling activity among the tracts of this cluster.

Cluster 4.—This cluster is identical in its geologic setting to the Nevada wilderness cluster 1 discussed by C. A. Sandberg in this circular. Both clusters are underlain by Tertiary lacustrine beds of the Lake Bruneau basin (Warner, 1977, 1980), but are covered at the surface mainly by slightly younger Tertiary volcanic rocks. Little is known about the few small windows of presumably postmature Paleozoic rocks that poke out from the extensive volcanic cover. Because the heating by volcanic rocks and minor areas of intrusive rocks may have raised the temperatures of some of the Tertiary source beds to optimum maturity, this cluster and Nevada cluster 1 are rated to have a low potential.

Cluster 5.—The three wilderness tracts in this cluster are underlain by Paleozoic sedimentary rocks along the continuous crest of the Bear River and Portneuf Ranges. A regional geologic map (Oriel and Platt, 1980) reveals that all three tracts have the same geologic setting and are contained in a large southward-plunging syncline that also contains the eastern tract of wilderness cluster 25 in Utah discussed in this circular by C. M. Molenaar and C. A. Sandberg. Conodont CAI values of 3 encountered in Idaho cluster 5 are slightly lower, possibly because of lesser sedimentary load, than CAI values of 3.5 in Utah cluster 25 (which is rated to have a low potential). CAI values of 3 indicate that hydrocarbons are at optimum maturation for both oil and gas generation. Although little likelihood exists of finding structural traps in the fault plate at the surface, traps may be found in underlying thrust plates at depth. Hence this cluster is rated to have a medium potential. The quantitative resource estimates, discussed in chapter A of this circular by B. M. Miller, were made as if all three tracts in cluster 5 were part of the Eastern Basin and Range province.

Clusters 6 and 7.—Three wilderness tracts lie in the northern part of the Wyoming-Utah-Idaho Overthrust Belt province that barely enters the southeastern part of Idaho. Cluster 6, in eastern Bonneville County, is rated to have a medium oil and gas potential. The surface area of this tract consists of volcanic cover (not prospective for oil and gas); however, several old, shallow wildcat wells drilled nearby indicate that sedimentary rocks having petroleum potential are present in the subsurface.

The two tracts in cluster 7 in Idaho and one tract in cluster 16 in Wyoming (see C. W. Spencer, Wyoming, chapter M) make up tract 4-613 (U.S. Bureau of Land Management, 1981), which straddles the Wyoming-Idaho State line in the vicinity of Alpine, Wyoming. These three tracts are grouped together for this discussion on the basis of geologic similarity and are rated to have a high oil and gas potential on the basis of their possessing geologic characteristics favorable for the occurrence of petroleum. The Darby thrust trends northwest into the eastern part of the tracts and the Absaroka thrust parallels the Darby trend in the central part of the tracts in the northern part of the Overthrust Belt province. A wildcat well, Allday No. 1 Government, was drilled in 1966 in the western part of the northern Idaho tract in cluster 7 to a depth of 5,760 feet. Live oil and gas shows were encountered in porous and fractured Ordovician limestones in the interval from 1,252 through 1,375 feet in the well.

The same formations, reservoir rocks, source rocks, and trapping structures are present here in the northern part of the Overthrust Belt, as well as a favorable maturation history, all in a framework similar to that in the productive southern area of the Overthrust Belt (R. B. Powers, chapter N, figs. 2-4).

SUMMARY

Of the 7,559,186 acres involved in this study for the assessment of the petroleum potential of the Wilderness Lands in Idaho, the potential acreage can be summarized as follows: high potential, 115.1 thousand acres; medium potential, 63.4 thousand acres; low potential, 804.7 thousand acres; low to zero potential, 1,023.7 thousand acres; zero potential 5,515.6 thousand acres; and unknown potential, 36.7 thousand acres. The high potential acreage occurs in the Overthrust Belt province, while the acreage with unknown potential forms the westernmost part of the Yellowstone National Park and occurs in volcanic terrane. The petroleum potential by acreage of all Wilderness Land categories in the Western United States is shown in this circular by B. M. Miller in table 1, chapter P.

REFERENCES CITED

American Association of Petroleum Geologists and U.S. Geological Survey, 1976a, Geothermal gradient map of North America: U.S. Geological Survey Geologic Maps of North America Series, scale 1:5,000,000.

———1976b, Subsurface temperature map of North America: U.S. Geological Survey Geologic Maps of North America Series, scale 1:5,000,000.

Bond, J. G., compiler, 1978, Geologic map of Idaho: Idaho Bureau of Mines and Geology, scale 1:500,000.

Blackstone, D. L., Jr., 1980, Tectonic map of the Overthrust Belt, Wyoming, southeastern Idaho and northeastern Utah, showing current oil and gas drilling and development: Wyoming Geological Survey Map 8A, 3rd edition, updated through July 31, 1980, scale 1:316,800 (1 inch = 5 miles).

Dolton, G. L., Carlson, K. H., Charpentier, R. R., Coury, A. B., Crovelli, R. A., Frezon, S. E., Khan, A. S., Lister, J. H., McMullin, R. H., Pike, R. S., Scott, E. W., and Varnes, K. L., 1981, Estimates of undiscovered recoverable conventional resources of oil and gas in the United States: U.S. Geological Survey Circular 860, 87 p.

Epstein, A. G., Epstein, J. B., and Harris, L. D., 1977, Conodont color alteration—an index to organic metamorphism: U.S. Geological Survey Professional Paper 995, 27 p.

Gutschick, R. C., Sandberg, C. A., and Sando, W. J., 1980, Mississippian shelf margin and carbonate platform from Montana to Nevada, *in* Fouch, T. D., and Magathan, E. R., eds., Paleozoic paleogeography of the west-central United States: Society of Economic Paleontologists and Mineralogists, Rocky Mountain Section, Rocky Mountain Paleogeography Symposium 1, p. 111–128.

Harris, A. G., Wardlaw, B. R., Rust, C. C., and Merrill, G. K., 1980, Maps for assessing thermal maturity (conodont color alteration index maps) in Ordovician through Triassic rocks in Nevada and Utah and adjacent parts of Idaho and California: U.S. Geological Survey Miscellaneous Investigations Series Map I–1249, 2 sheets.

Isaacson, P. E., assisted by Bachtel, S. L., and McFaddan, M. D., 1983, Stratigraphic correlation of the Paleozoic and Mesozoic rocks of Idaho: Idaho Bureau of Mines and Geology, 1 sheet.

Maughan, E. K., 1975, Organic carbon in shale beds of the Permian Phosphoria Formation of eastern Idaho and adjacent states—a summary report, *in* Wyoming Geological Association Guidebook, 27th Annual Field Conference: p. 107–115.

McDonald, R. E., 1973, Great Basin Tertiary has potential: Oil and Gas Journal, v. 71, no. 33, 34, 35, p. 146–158, 86–90, 132–134.

Oriel, S. S., and Platt, L. B., 1980, Geologic map of the Preston 1 degree by 2 degree quadrangle, southeastern Idaho and western Wyoming: U.S. Geological Survey Miscellaneous Investigations Series Map I–1127, Scale 1:250,000.

Poole, F. G., and Sandberg, C. A., 1977, Mississippian paleogeography and tectonics of the Western United States, *in* Stewart, J. H., Stevens, C. H., and Fritsche, A. E., eds., Paleozoic paleogeography of the Western United States: Society of Economic Paleontologists and Mineralogists, Pacific section, Pacific Coast Paleogeography Symposium 1, p. 67–85.

Poole, F. G., Sandberg, C. A., and Boucot, A. J., 1977, Silurian and Devonian paleogeography of the Western United States, *in* Stewart, J. H., Stevens, C. H., and Fritsche, A. E., eds., Paleozoic paleogeography of the Western United States: Society of Economic Paleontologists and Mineralogists, Pacific section, Pacific Coast Paleogeography Symposium 1, p. 39–65.

Sandberg, C. A., 1975, McGowan Creek Formation, new name for Lower Mississippian flysch sequence in east-central Idaho: U.S. Geological Survey Bulletin 1405–E, 11 p.

———1980, Use of Devonian conodonts in petroleum exploration, Western United States [abs.]: American Association of Petroleum Geologists Bulletin, v. 64, no. 5, p. 780.

Sandberg, C. A., and Clark, D. L., eds., 1979, Conodont biostratigraphy of the Great Basin and Rocky Mountains: Brigham Young University Geology Studies, v. 25, pt. 3, 190 p.

Sandberg, C. A., Grogan, D. R., and Clisham, T. J., 1979, Mississippian source rocks in Utah and Idaho: U.S. Geological Survey Professional Paper 1150, p. 28–29.

Sandberg, C. A., Hall, W. E., Batchelder, J. N., and Axelsen, Claus, 1975, Stratigraphy, conodont dating, and paleotectonic interpretation of type Milligen Formation (Devonian), Wood River area, Idaho: U.S. Geological Survey Journal of Research, v. 3, no. 6, p. 707–720.

Sandberg, C. A., and Poole, F. G., 1977, Conodont biostratigraphy and depositional complexes of Upper Devonian cratonic-platform and continental-shelf rocks in the Western United States, *in* Murphy, M. A., Berry, W. B. N., and Sandberg, C. A., eds., Western North America; Devonian: California University, Riverside, Campus Museum Contribution 4, p. 144–182.

Sando, W. J., Sandberg, C. A., and Gutschick, R. C., 1981, Stratigraphic and economic significance of Mississippian sequence at North Georgetown Canyon, Idaho: American Association of Petroleum Geologists Bulletin, v. 65, no. 8, p. 1433–1443.

Sweet, W. C., Harris, A. G., Sandberg, C. A., and Wardlaw, B. R., 1981, Conodonts; guides to biostratigraphy and geothermometry in the western United States, *in* Montana Geological Society Field Conference and Symposium Guidebook to Southwest Montana: p. 133–137.

Swetland, P. J., Patterson, J. M., and Claypool, G. E., 1978, Petroleum source-bed evaluation of Jurassic Twin Creek Limestone, Idaho-Wyoming thrust belt: American Association of Petroleum Geologists Bulletin, v. 62, no. 6, p. 1075–1080.

U.S. Bureau of Land Management, 1981, State of Idaho wilderness status map, scale 1:1,000,000.

Warner, M. M., 1977, The Cenozoic of the Snake River Plain of Idaho, *in* Wyoming Geological Association Guidebook, 19th Annual Field Conference: p. 313–326.

———1980, S. Idaho, N. Nevada, southeastern Oregon—prime exploration target: Oil and Gas Journal, v. 78, no. 18, p. 325/341 (not inclusive).