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(Outcrops of Metaline Limestone in
Stevens and Pend Oreille Counties)

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Introduction

The purpose of the field work completed during the summer of 1976 was to collect information about the nature and location of outcrops of the Metaline Limestone in Stevens and Pend Oreille Counties, Washington. This information will be used to help me select and define a Ph.D. dissertation project on the Metaline. It was my intention to familiarize myself with the regional outcrop pattern and to locate and describe any features within the rocks that would yield stratigraphic or petrographic information.

I would like to thank Dr. J. W. Mills, Mr. J. E. Schuster and Mr. B. W. Hurley for their guidance through the geography and geology of the area. I am also grateful to the Washington Department of Natural Resources for the support given me last summer. The field work was also supported in part by a grant from Sigma Xi.

The Metaline Limestone outcrops in a NE-SW trending belt that passes through Stevens and Pend Oreille Counties. The Formation has been described as far south as Ione Washington and to the west, reference has been made to Metaline Rocks at Northport Washington (Dings and Whitebread, 1965, p. 9). At the Canadian border, the Metaline Limestone becomes known as the Nelway Formation and continues to outcrop parallel to the axis of the Kootenay Arc.

The Metaline Limestone has been divided into three main lithologic units (Dings and Whitebread, 1965, p. 10). The lower thin-bedded limestone-shale sequence was observed and sampled at two locations; the Lehigh Portland Cement Company Quarry on Quarry Hill southeast of Metaline Falls, and at Marble Creek north of the City of Colville. The intermediate or middle light-gray bedded dolomite unit was observed at Crescent Lake and in outcrops along State Route 31 south of the lake (Fig. 1). The upper, gray massive limestone unit was sampled on the Lead King Hills east of the Lead King Lakes (Fig. 1).

After preliminary reconnaissance of the area was completed, more accessible outcrops were examined in some detail. Samples, oriented where possible, were taken at observable changes in lith-

ology or where sedimentary structures were obvious and could be sampled.

For the continuation of the project, I will formulate a more detailed sampling procedure based on laboratory study this winter. Critical sampling locations may then be chosen and a more in depth study can be directed into areas of special interest such as the contact zone between the middle and upper units of the Metaline, and those parts of the Metaline containing abundant sedimentary textures and structures.

Study of the Metaline Limestone in Stevens and Pend Oreille Counties is hampered by structural complications, poor outcrops and post depositional recrystallization. In many places, the regional structure may cause repetition or omission of parts of the succession. The structure has also imposed a cleavage and joint system on the rocks that may distort or obliterate bedding. Outcrops are not extensive, and exposures are generally small due to the glacial cover over the area. Neomorphism and dolomitization as well as post-depositional solution are extensive in parts of the formation, and these features obscure primary depositional textures and structures.

Due to the structural complications, a definitive Metaline stratigraphy with measured sections may not be an attainable objective in the near future. It is possible, however, that certain "petrographic" or parastratigraphic units (Krumbein and Sloss, 1963, p. 333) may be discerned within the Metaline. If such units are definable, perhaps they may be of regional extent and become tools for the location of specific horizons and top-bottom relationships within the formation. Facies changes, represented as vertical changes in rock type, are environmentally significant, and if these can be identified, a regional picture of sedimentation in the middle Cambrian of this area may emerge.

Observations

The most important aspect of the study to date seems to be the recognition of sedimentary structures and textures previously unidentified in the Metaline Limestone. These features including burrows, contorted laminations, nodular bedding and fossils can be

environmentally sensitive, and if this proves to be the case, the features will help define the environment of deposition of the unit. If these textures and structures occur sequentially, they may become reference horizons within the Metaline and aid in the exploration for mineral zones within the formation.

From my impressions of the rocks of the Metaline Limestone, I have constructed a preliminary framework of possible depositional environments for the different units of the Metaline.

The lower, thin-bedded limestone-shale sequence of the Metaline Limestone was observed at Marble Creek (NW¼, NW¼, Sec. 27, T. 37N, R.40E.). The outcrop at this location contains a gray, thin to medium-bedded limestone with argillaceous partings and thin laminae of terrigenous clay. Above this lithology, the lower unit contains an arenaceous oolite, ooid-and oncolite-bearing beds that are interbedded with further argillaceous lime muds and tan-weathering terrigenous muds. The upper part of the section at Marble Creek contains burrowed calcilutites containing fragmented trilobite tests. The lower unit was further sampled at Quarry Hill (SW¼, NE¼, Sec. 27, T.39N, R.43E), where it appears to be stratigraphically higher than the lower Metaline rocks at Marble Creek (Dings and Whitebread, 1965, p. 11). The limestone in the quarry is pod-like, black and pyritiferous and contains abundant trilobite remains that are well preserved, with intact carapaces.

The lower unit appears to represent at least three depositional environments that migrated laterally through time in response to change in water depth and clastic influx. These sites were perhaps close to a shelf edge with variable water depths. At times, a relatively low energy environment existed, perhaps in shallow sublittoral waters (lower section at Marble Creek). Progradation in this environment may have caused shoal areas and channels to develop where ooids and oncolites could form. The interbedding of the two lithologies implies an oscillation of water depths through time. The occurence of pyrite and black limestone at Quarry Hill indicates deep water conditions and a reducing environment at the sediment-water interface. The preservation of the trilobites indicates low energy and lack of burrowing organisms.

At present, I have not seen the contact between the lower and

middle units of the Metaline Limestone, and cannot as yet draw conclusions about any relationships that may exist at the contact or between the two units.

The middle unit of the Metaline Limestone was observed at Crescent Lake (NW¼, NE¼, Sec. 12, T.40N, R. 43E). It is composed of light-gray dolostone with discontinuous laminae and pods of black and "salt and pepper" dolostone. Randomly distributed pods of "zebra" dolostone were also observed. The rocks are locally vuggy and contain stylolites. Outcrops along State Route 31 south of Crescent Lake show the same lithologies as above, as well as brecciated zones containing angular pods and fragments of black dolostone suspended in light-gray and white crystalline dolostone. The middle Metaline was also observed in the Clugston Creek area where contorted laminae, cut and fill structures and salt and pepper dolostone were found.

The contact between the middle and upper units of the Metaline Limestone was observed at Uncle Sam Mountain (C. SW¼, Sec. 2, T. 37N, R. 39E) and at the Lead King Hills (C. Sec. 27, T.40N, R.43E). At both locations the contact was gradational. The rocks in the contact zone at the Lead King Hills showed an alteration between tan sugary dolostone, black crystalline dolostone, and beds of gray limestone containing stylolites. At Uncle Sam Mountain, the transition zone includes a dolostone and a calcitic dolostone grading into a gray limestone.

The transition interval between the middle and upper units of the Metaline Limestone is the key to an accurate interpretation of the origin of the two units and the origin of the dolomite in the middle unit. No textures or structures indicative of sabkah type supratidal deposition were observed in the field. Further detailed petrographic investigation of this zone needs to be performed and should be directed toward determination of any environmentally sensitive structures within these rocks. Rip-up clasts, algal-mat laminae, mudcracks and lack of autochthonous fauna have been described as primary evidence for an environment where penedepositional formation of dolomite is possible (Lucia, 1972, p. 161). The absence of these features may then be taken as major evidence for a secondary origin of the dolomite. If this is the case, it

becomes likely that the observed contact between the middle and upper Metaline is diagenetic, and is not of depositional origin.

The upper unit of the Metaline Limestone, observed at the Lead King Hills (C., Sec. 27, T.40N, R.43E), is a light-gray, massive, burrowed calcilutite. It has been bioturbated and contains lenses, stringers and occasional pods of argillaceous material. In many areas stylolites which are parallel or subparallel to bedding were observed.

The lime mud of the original sediment may have been deposited in a shallow, sublittoral environment. It is not clear as yet whether this environment existed seaward of a high energy zone, or shoreward in an extended low energy epeiric belt parallel to the ancient shoreline (Shaw, 1964, p. 13). The generally low energy conditions existing in both of these environments could produce abundant fine-grained carbonate muds. The observed burrowing indicates the existence of organisms capable of destroying primary sedimentary textures and structures with their feeding habits, and this bioturbation could yield a massive sediment with discontinuous concentrations of argillaceous material along relict bedding surfaces. Some of these argillaceous stringers also may represent organic and insoluble material that was trapped along solution pathways during stylolitization.

Conclusions

The three units described in the Metaline Limestone contain a variety of different rock types and sedimentary structures. Presumably, these differences reflect changing depositional environments through Metaline time, and diagenetic alterations imposed on the rocks at a later time. A second field season is planned during which the Metaline Limestone can be studied in greater detail.

References

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Krumbein, W. C., and Sloss, L. L., 1963, Stratigraphy and Sedimentation; W. H. Freeman and Company, 660 p.

Lucia, F. J. , 1972, Recognition of Evaporite-Carbonate Shoreline Sedimentation; Soc. Econ. Paleontologists and Mineralogists, Spec. Publ. no. 16, p. 160-190.

Shaw, A. B., 1964, Time in Stratigraphy; McGraw-Hill Inc. 365 p.

Field Notes, Summer 1976

*= Sample Taken

Upper Metaline Limestone, Lead King Hills. C. Sec. 27, T.40N, R.43E.

76-29 * Alternation of dolostone and limestone. This sample is a gray dolostone with calcite filled vugs.

76-28 * Dark gray to black crystalline dolostone in a transition zone to dark gray to black crystalline dolostone containing calcite filled vugs, vuggy dolostone, limey dolostone and finally to a gray limestone. N30E 33NW

76-27 * Massive gray limestone with no visible bedding. Rock is burrowed with some ?dolo-mottling around burrows which are randomly oriented in the rock. Mottling is tan on gray. Many calcite veins cut the rock randomly.

76-26 Massive gray limestone randomly cut by bands of dolomite or silica that stand in relief on weathered surface. Bands seem to outline pods of limestone. Pods are 1-2' in long diameter. The bands themselves may be solution features.

76-25 * Gray limestone with calcite filled burrows. Shows a light-dark gray mottling on weathered surface. May be medium-bedded 6-8" to 1-2'. N32E 68NW.

76-24 * Gray limestone. Appears burrowed and in places burrows are filled with crystalline silica or dolomite that was concentrically deposited and now replaces burrow filling. These features stand in relief on weathered surfaces.

76-23 * Gray limestone. Structureless, a few siliceous "nodules". Pockets of coarse calcite. ?burrows. Bedding not apparent.

76-22 * Black coarsely crystalline dolostone with sphalerite and siliceous veins. Thick-bedded to massive with vugs filled with coarse calcite and dolomite. Becomes more calcitic upward.

Upper Metaline Limestone, SE¼ Sec. 22, T.40N, R.43E.-SW¼, SW¼, Sec. 23, T.40N, R.43E.

76-52 * Pods of argillaceous material within the gray limestone. Pods may be as large as 6-8" in diameter. Color of pods is gray to green-brown. ?Burrows. Argillaceous material also in discontinuous layers 6-8" thick and 1-3' long. N10E 25NW.

76-51 * Gray limestone with burrows and stylolites. Appears laminated. N9E 15NW.

76-50 Coarse crystalline dolostone with brown mottling as vugs and lines running through a gray limestone. Coarse calcite

fills vugs. Becomes major part of the rock in places. Vugs abundant. They are either from dolomitization or they are relict burrows.

76-49 * Coarsely crystalline gray dolostone, brown mottling with coarse crystalline calcite as vug filling.

76-48 * Gray vuggy dolostone in small outcrop in covered bank.

76-47 * Gray limestone with burrows and stylolites. Solution stringers with argillaceous deposits randomly distributed in the rock.

76-46 * Massive gray limestone with burrows and some solution features.

76-45 Laminated gray limestone. Laminations are crinkley and discontinuous. Appear to be solution stringers and concentrations of argillaceous material on ?bedding surfaces. Rock is also burrowed. In outcrop, zones of less laminated gray limestone alternate with well-laminated zones. In places, pod-shaped concentrations of argillaceous material are attached to the stringers. Pods are up to 2" in diameter. In places, these features look like a burrow system. N35E 19NW.

Middle Metaline Limestone, State Route 31 South of Crescent Lake, SE$\frac{1}{4}$, SW$\frac{1}{4}$, Sec. 12, T.40N, R.43E.

76-41 15-20' salt and pepper dolostone with gray dolostone as pods and layers 1-2' thick.

76-40 35-40' gray dolostone. Massive to thick-bedded. Layer of salt and pepper dolostone 1-2' thick at top. N25E 34NW.

76-39 Lower section 30' of alternating (randomly) salt and pepper with gray dolostone. Gray dolostone as pods within the black dolostone and black as pods in the gray. 30-40' of gray dolostone with black bands parallel to ?bedding. 20' of gray dolostone in two ?beds. 5' mottled zone at top of lower unit. N25E 37NW.

76-38 * Zone of breccia 15' thick at base of the outcrop. Above breccia is grey dolostone with zones of light-dark gray mottled dolostone. Becomes a zone of salt and pepper dolostone 2-3' thick. This becomes brecciated at the top of the outcrop. N37E 34NW.

76-37 * Pods of black salt and pepper dolostone suspended at random orientation within a light gray dolostone. It is a breccia with white bands in the black dolostone.

76-36 * Light gray dolostone. Massive becoming black dolostone. There is a zone of transition through a mottled rock, black with white, where white zones are randomly distributed in

a black matrix.

Middle Metaline Limestone, Crescent Lake, NW¼, NE¼, Sec. 12 T.40N, R.43E

76-35 Massive, light-gray dolostone. Becomes thick-bedded with argillaceous partings 1-6" thick between dolostone layers. Dolostone becomes laminated with dark discontinuous laminae upward. N40E 40NW.

76-34 * Transition from gray to salt and pepper dolostone. Lower contact is transitional, becoming a cross-cutting contact with a sharp upper boarder and irregular, undulatory lower surface. Becomes breciated in places.

76-33 * Transition from gray to salt and pepper dolostone.

76-32 * 6-8' bed of black and salt and pepper dolostone. Black crystalline dolostone with white blebs of dolostone and white discontinuous laminae. Transitional through gray dolostone with patches of zebra dolostone. There are also patches of vuggy massive or laminated gray dolostone within the black beds. Over these are 6" of gray dolostone and another 2' black layer. There seems to be a regular sequence of 1-5' black layers and 5-10' gray layers. Contacts between gray and black dolostone are locally sharp or gradational. Contacts may parallel the apparent bedding or cut across it.

76-31 * Light gray dolostone with discontinuous laminae of dark material. Laminae undulatory. May be bedded, 1-2' or massive. ?solution features. Vuggy in places. Laminations parallel to bedding. Pods of black crystalline dolostone locally. N10E 27NW.

Lower Metaline Limestone, Quarry Hill, SW¼, NE¼, Sec. 27, T.39N, R.43E.

76-54 * Shale layer with pyrite on bedding planes. 8' of black calcilutite with thin 2-4" beds that appear laminated on weathered surface. Bedding is undulatory but less than below. Beds more continuous. In places, shale layers enclose pods of black limestone.

76-53 11' black-dark gray limestone with small eyes of white calcite. Thin-bedded, 3-8". Bedding surfaces undulatory. Contains white veins, ?burrow fillings. Beds pinch and swell in lenses. Two grain sizes, microcrystalline calcite and coarser, fine calcarenite with fossil fragments. Shaly partings between layers. N8E 25W.

Further sampling and collection at this location is planned during the second field season.

Lower Metaline Limestone, Marble Creek, NE¼ Sec. 28, T.37N, R. 40E.

76-70 Evidence of folding and minor faulting. Calcite filled gash fractures, phyllitic sheen on argillaceous layers and small secondary folds were observed.

76-69 35' alternating gray, oncolitic and oolitic limestone with fine grained calcilutite with argilaceous partings. Oncolite layers are 1-2' thick, calcilutite layers are 4-5' thick. Layers of tan-weathering limestone are found as pods and lenses in the thicker units.

76-68 6" oolitic layer.

76-67 4-5' argillaceous limestone.

76-66 * 5' gray limestone with oncolites becoming more common upward. Ooids in matrix between oncolite grains. Contains stringers of argillaceous material that surround the oncolites.

76-65 * 60' massive gray limestone. Burrowed, with argillaceous partings. May also be thin bedded, ½-2' thick. Contains 1-3" layers of intraclastic or oncolitic calcarenite at random intervals through the section. Grain size generally coarsens upward.

76-64 5' covered interval followed by 6' gray crystalline limestone with a small amount of tan mottling. Contains blebs of argillaceous material. Interbedded coarser grained gray limestone that is fossiliferous and intraclastic.

76-63 * 65' of gray limestone with argillaceous partings. These are very common and almost form a boxwork in places. Varies from massive to thin-bedded. Argillaceous material looks phyllitic. N70E 35SW.

76-62 * 3-5' dolomitic limestone with burrows filled with calcite and occasional quartz grains. Massive gray calcilutite.

76-61 * 15' covered interval overlain by 18" of gray limestone with rounded quartz sand grains and fossil fragments in a mud matrix. Not grain supported.

76-60 * 2' calcarenite. ?framework rock composed of ooids and well rounded quartz sand grains.

76-59 * 1-2' gray limestone with argillaceous partings at 6" intervals. Interlayered with thin-beds of fossiliferous calcarenite containing rounded quartz grains. N80E 26SW.

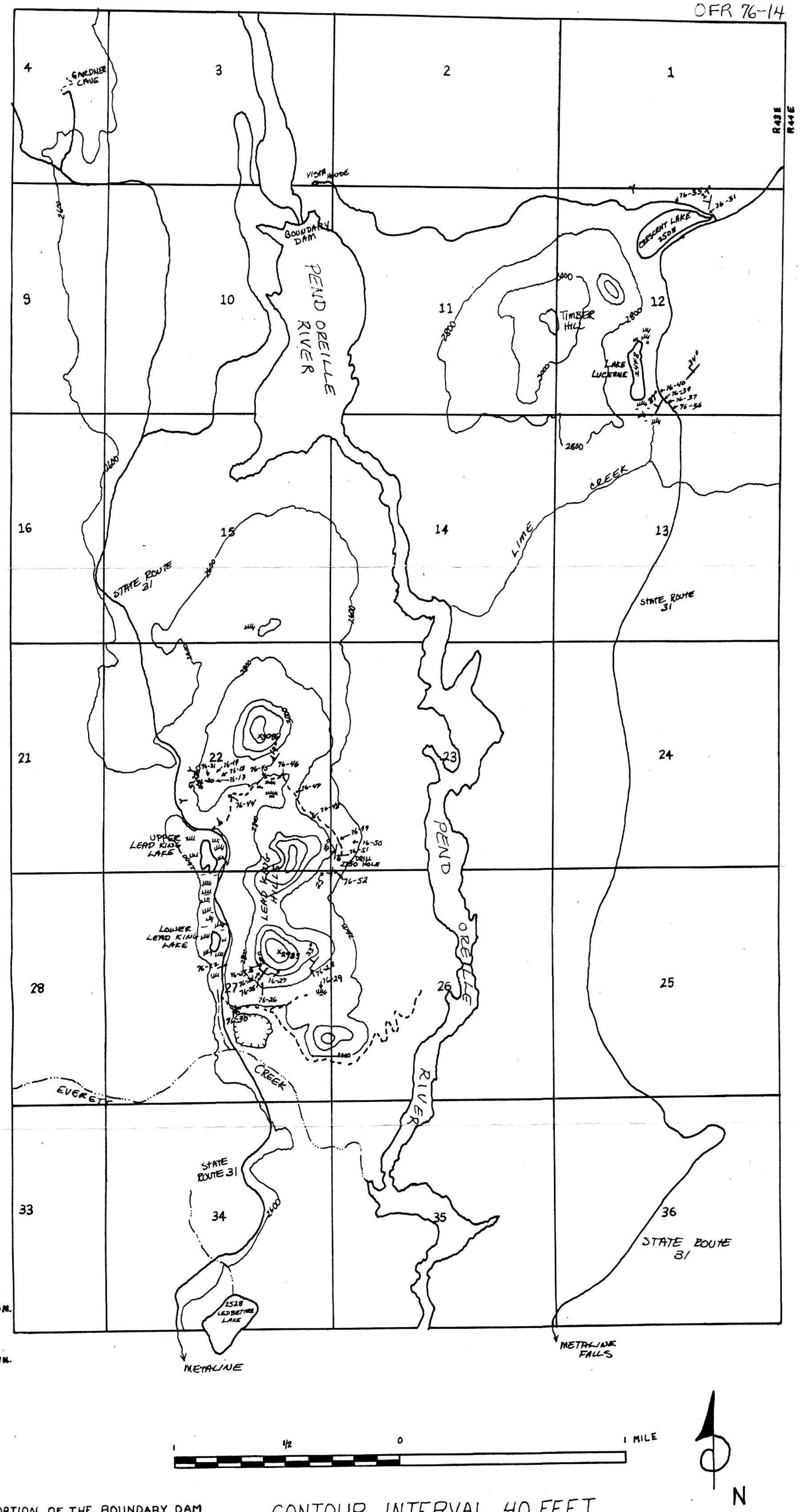
76-58 5-8' interbedded oolitic beds with burrowed, mottled, gray fine-grained limestone.

76-57 Medium-dark gray crystalline limestone. Contains trilobite

fragments and other biogenic debris. Burrowed and ?re-crystallized. Contains argillaceous stringers in places.

76-56 Coids and oncolites becoming very abundant. Oncolites are well-laminated. The rock in places is a framework rock with good intergrain contacts between the oncolites.

76-55 Black limestone with argillaceous partings. Pelletic, pyrite bearing, burrowed. Inter-bedded mudstones and fine calcarenite containing small fossil fragments.



A PORTION OF THE BOUNDARY DAM 7.5 MINUTE TOPOGRAPHIC MAP, PEND OREILLE CO. WASHINGTON

CONTOUR INTERVAL 40 FEET

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Figure 1