British Columbia Geological Survey
Geological Fieldwork 1980

NORTHERN BRITISH COLUMBIA

AKIE RIVER PROJECT (94F)

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INTRODUCTION

Regional mapping and detailed stratigraphic studies of host rocks for stratiform barite-lead-zinc deposits were continued in the Akie River area of northeastern British Columbia (Fig. 9). This project, initiated in 1979, was accelerated in 1980 in response to intense exploration activity generated by the announcement of the discovery of a major deposit (+30 million tonnes, 10 per cent lead and zinc, 46.65 grams per tonne silver) at Cyprus Anvil's Cirque property (MI 94F-8). The 1980 fieldwork involved two 2-man helicopter-supported field crews doing 1:50 000-scale mapping and measurement of stratigraphic sections, mainly from strategically located fly camps. A rectangular area, approximately 50 kilometres long and 25 kilometres wide extending from Kwadacha Wilderness Park to the Akie River, has now been mapped. Coverage will be extended to both the north and south during the 1981 field season.

Geologic data is currently being compiled on a 1:50 000-scale orthophoto base* and will be released as a preliminary map as soon as possible. This report deals mainly with the stratigraphic setting of mineral deposits in the area and possible facies relationships between these deposits and their host rocks. A model is presented for these facies relationships as deduced from fieldwork completed during the 1979 and 1980 field seasons. Detailed petrographic, geochemical, and paleontological studies of the Devonian host rocks are currently in progress and will help to refine this model as data becomes available. In addition, Kevin Heather, a fourth year student at the University of British Columbia, has started a thesis study on the Ordovician stratigraphy of the map-area based on his fieldwork during the 1980 field season.

TECTONIC SETTING

The Akie River area is part of the Rocky Mountain Thrust and Fold Belt of northeastern British Columbia (Fig. 9). This part of the thrust and fold belt consists of fault-bounded northwest-trending synclinoria of Early Paleozoic basinal facies rocks of the Kechika Trough separated by anticlinoria of Cambrian and older rocks. During Early Paleozoic time, prior to the postulated 400-kilometre right lateral offset along the transverse Rocky Mountain Trench fault system (Templeman-Kluit and Blusson, 1977), the Kechika Trough was bounded by the MacDonald platform and craton to the northeast and the Pelly—Cassiar platform to the southwest. The Kechika Trough is a southeasterly extension of the larger Selwyn Basin in the Yukon.

GENERAL GEOLOGY

The geology of the Driftpile Creek—Akie River barite-lead-zinc district is shown on Figure 10. A previous report (MacIntyre, 1980) has already described the geology and mineral occurrences of the district. This,

*Available through Surveys and Mapping Branch, Ministry of Environment, Victoria (Project 80-030-T-O, Ware).

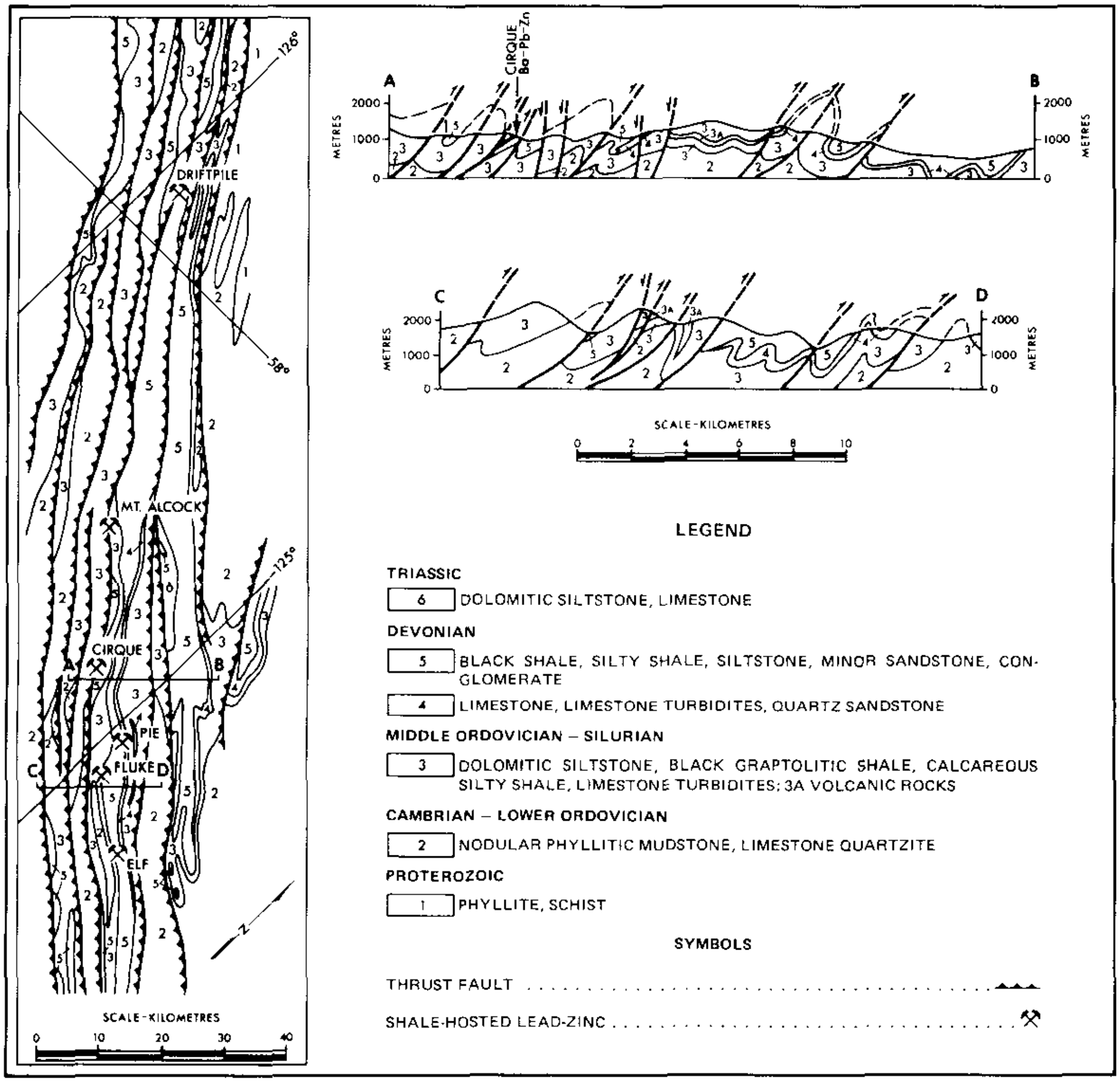

Figure 10. General geology, Driftpile—Akie River barite-lead-zinc district.

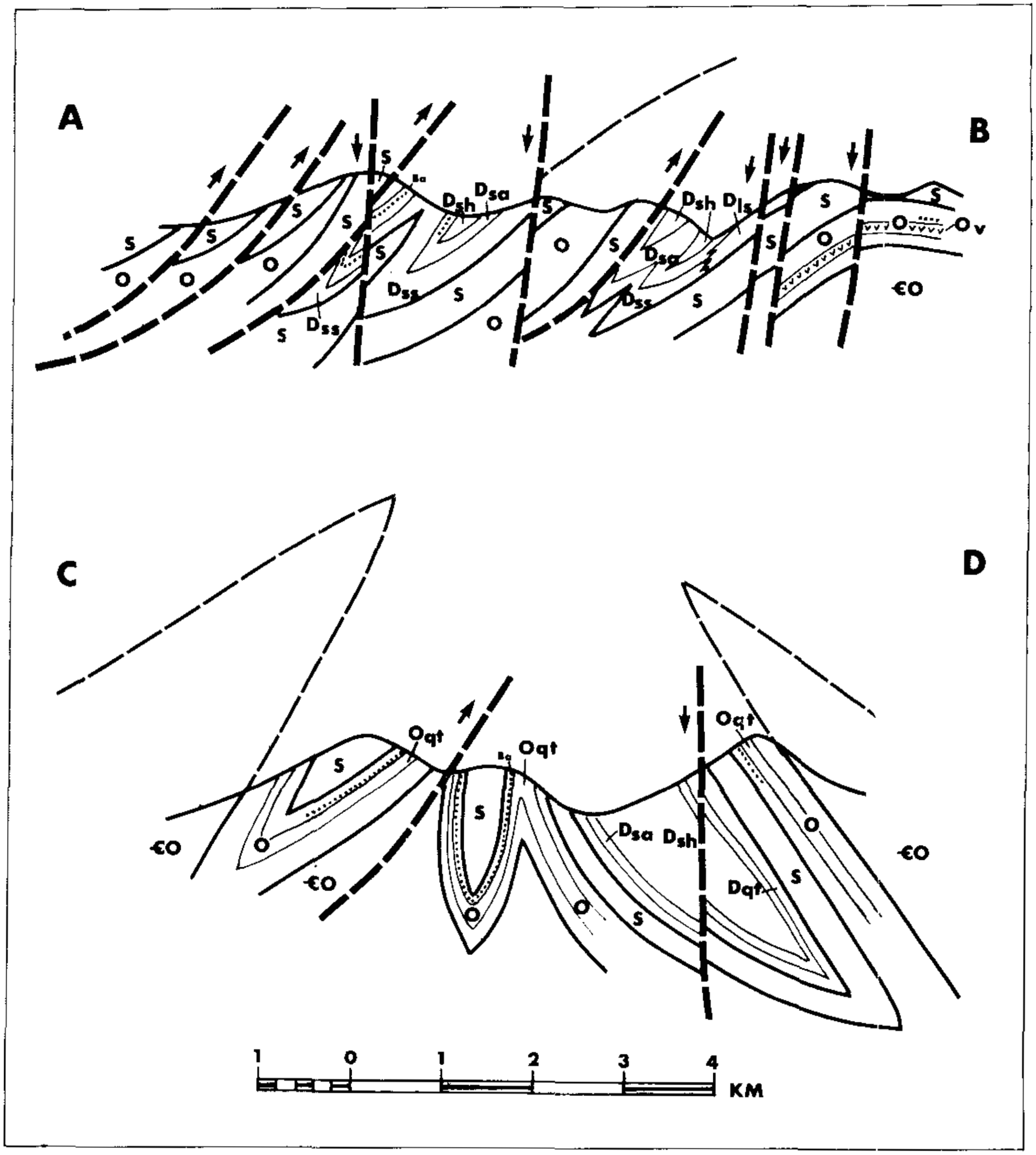

Figure 11. Structural sections across the eastern (A–B) and western (C–D) shale belts, Akie River area. *See* Figure 12 for location of sections and Table 1 for explanation of sedimentary facies designations. **Note:** vertical scale 1.5 x horizontal scale.

report deals mainly with the Ordovician, Silurian, and Devonian stratigraphy of the Akie River area (94F/6, 7, 10, 11) and the stratigraphic and structural setting of the bedded barite-sulphide deposits that occur within these rocks.

STRUCTURE

The Early Paleozoic rocks of the Akie River area are preserved within a series of parallel northwest-trending synclinoria that are bounded by southwest-dipping thrust faults. These structures are the products of northeast-directed compression during the Columbian and later orogenies. The westernmost synclinoria are composed of tight, overturned, asymmetric fold structures with southeast-dipping axial surfaces. Imbricate thrust faults typically occur along axial surfaces resulting in stacking of thrust plates and overriding of younger strata by older rocks (Fig. 11).

The intensity of deformation and degree of supracrustal shortening and thickening appear to decrease eastward across the Akie River area. The predominant structural style of the eastern shale belt (Fig. 11) is one of large-scale folding within a synclinorium that is being overridden from the southwest and northeast by anticlinoria of older strata. Axial surfaces of folds generally dip away from the core of the synclinorium.

Post-orogenic normal faults are also common. The downthrown block is typically to the west with displacements varying from less than 10 to greater than 200 metres. The faults offset earlier thrust faults in the eastern shale belts.

STRATIGRAPHY

Location of stratigraphic sections and the distribution of Devonian rocks in the Akie River area are shown on Figure 12. Stratigraphic sections are illustrated on Figure 13 and Table 1 (pages 46 and 47) summarizes the various sedimentary facies delineated during the current mapping project.

ORDOVICIAN

In the Akie River area phyllitic nodular mudstones and siltstones of the Cambrian to Lower Ordovician Kechika Formation (Cecile and Norford, 1979; Taylor, 1979; Taylor, *et al.*, 1979) are unconformably overlain by a succession of Early Ordovician to Late Devonian basinal facies limestone, siltstone, shale, and minor volcanic rocks. These rocks exhibit facies variations across the map-area which suggest that the basin to platform transition to the east was very abrupt with a relatively steep basinward slope. Within the Kechika Trough three major transgressive depositional cycles, each beginning with shallow water carbonate and associated turbidites and grading up-section into progressively deeper water black shales, occur in the stratigraphic record. These depositional cycles, which are separated by unconformities, conveniently divide the stratigraphy into well-defined formations (Figs. 14 and 15). Cecile and Norford (1979) proposed that the Ordovician and Silurian cycles are correlative with the Road River Formation. More recently Thompson (personal communication) has suggested elevating the Road River to group status with inclusion of the Devonian part of the section in this group.

The stratigraphy of the Ordovician and Silurian parts of the Road River 'Formation' in the Ware (94F) map-area have been described by Taylor, *et al.* (1979) and Cecile and Norford (1979). In the Akie River area, the base of the Road River 'Formation' includes cream, beige, and reddish brown-weathering, laminated, and calcareous siltstone and shale (O_{ss}) with limestone turbidite (O_{lt}) interbeds. The latter are probably derived from the Skoki limestone (O_{ls}) which occurs east of the project area (Cecile and Norford, 1979). These rocks grade up-section into black shales and minor cherts (O_{sh}) which contain Middle Ordovician graptolite assemblages. The shales are incompetent relative to underlying and overlying strata and are intensely sheared and folded with pervasive cleavage. Upon weathering these rocks decompose to a black carbonaceous mud.

Discontinuous volcanic horizons (O_v) occur near the base of the Ordovician black shale unit in the western shale belt. The best exposures occur in the vicinity of the Pie prospect where a greenish grey-weathering, massive microdioritic flow, up to 50 metres thick, overlies graptolitic black shale and chert and is overlain by interbedded shale and orange to brown-weathering, carbonate-rich vitric, crystal, and lapilli tuff. These rocks are probably the product of periodic volcanic activity along a deep-seated rift zone. Minor nodular barite was noted in highly altered tuffs at section 15 (Fig. 13).

Close to the Skoki limestone (O_{ls}) shale-out, along the eastern margin of the shale basin, a sequence of quartzose proximal turbidites (O_{qt}) occurs in the upper black shale unit of the Ordovician section. This turbidite unit is 150 metres thick near the southern limit of the easternmost shale belt and thins gradually to the north, east, and west. The massive grey-weathering quartz sandstone and siltstone beds that are characteristic of this unit are separated by thin black shale interbeds with late Middle to early Upper Ordovician graptolite assemblages (Cecile and Norford, 1979). This unit therefore lies stratigraphically above the Middle Ordovician volcanic unit. At the Sika showing, an extensive barite bed, up to 1 metre thick, overlies the quartzose turbidite unit (sections 31, 32, and 35, Fig. 13).

SILURIAN

Road River shales are unconformably overlain by as much as 800 metres of orange to brown-weathering siltstone (S_{sl}) and minor limestone (S_{ls}) of Silurian age. This unit is relatively competent and resistant and typically caps peaks and ridges throughout the project area, particuarly where it has been thrust over younger, less resistant rocks.

Platy, thin laminar-bedded and blocky, thick flaser-bedded dolomitic siltstone with minor grey and orange-weathering limestone and dolostone interbeds dominate the Silurian succession. Generally, these rocks are strongly bioturbated. Spiral feeding trails, siliceous sponge spicules, sponge imprints, and poorly preserved graptolites are also common. Cecile and Norford (1979) suggest an early Middle Silurian (Wenlockian) age based on sponge and graptolite taxa from the dolomitic siltstone part of the succession.

In the Akie River area the base of the Silurian section is marked by a 10 to 20-metre-thick unit of grey, blocky weathering massive limestone (S_{ls}) or dolostone (S_{ds}) or by limestone turbidites (S_{lt}). Up-section these rocks grade into a unit of interbedded black chert and grey laminated to crosslaminated limestone (S_{sa}) which is locally overlain by dark grey-weathering silty shale and siltstone turbidites (S_{ss}) containing Early Silurian (Llandovery) graptolites (Cecile and Norford, 1979). The thick dolomitic siltstone unit (S_{sl}) unconformably overlies these basal rocks, and, in places, has been deposited directly on Middle Ordovician black shale.

In the eastern shale belt, a distinctive unit of orange-grey-weathering dolomitic quartz sandstone and siltstone turbidite overlies the basal limestone turbidite (S_{lt}) unit of the Silurian section. Thin beds of grey barite were noted in this unit at section 35 (Fig. 13).

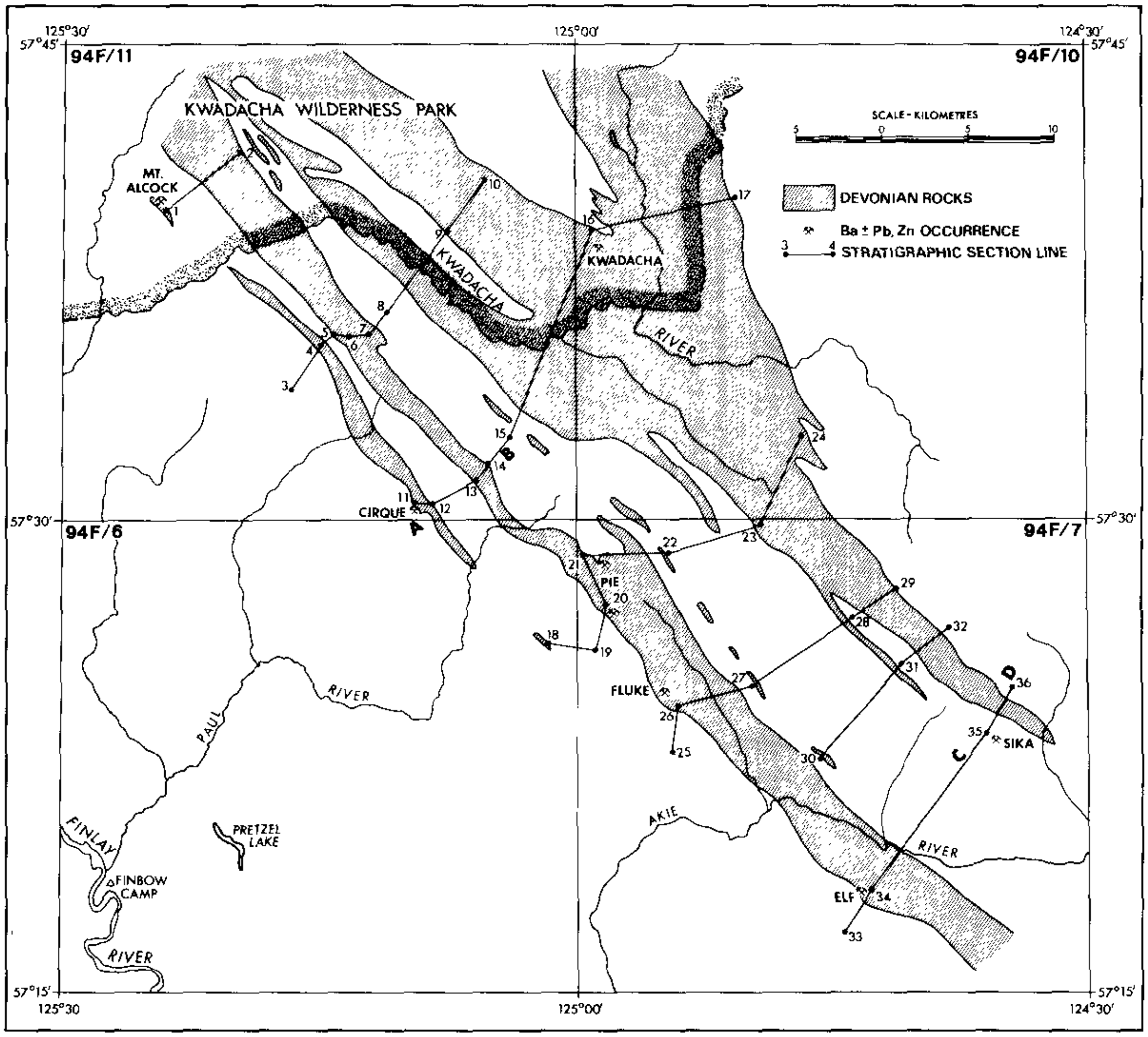

Figure 12. Location of stratigraphic sections and distribution of Devonian rocks in Akie River project area.

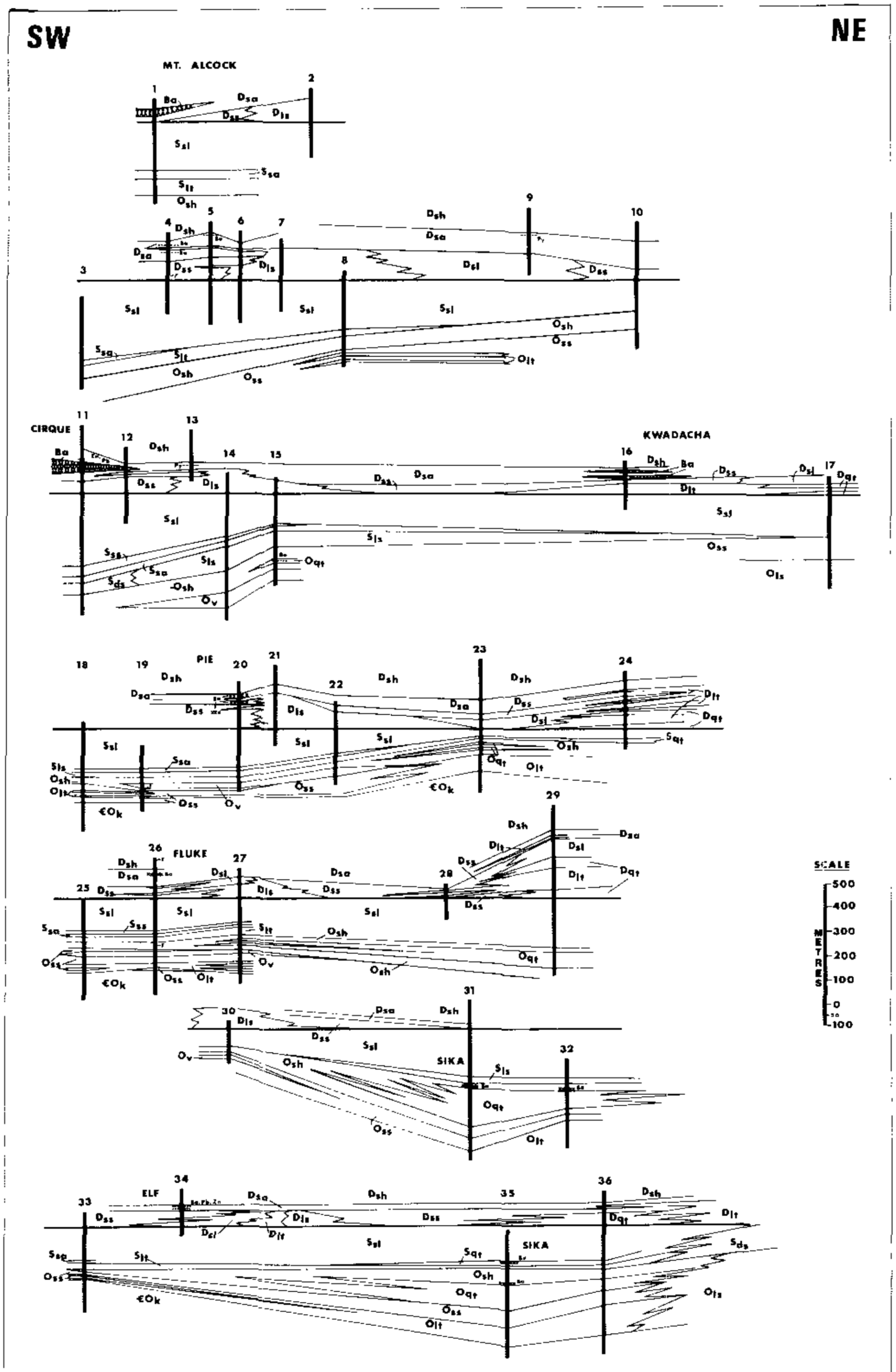

Figure 13. Stratigraphic sections, Akie River area. Note that the thicknesses of sedimentary facies are only approximate in most cases. Sections positioned by location of traverse, with no correction made for supracrustal shortening due to faulting and folding.

The stratigraphy of the Silurian section suggests early deposition of shallow water limestone and dolostone and their associated turbidite facies was followed by a marine transgression and deposition of progressively deeper water clastic rocks. This cycle was terminated by a period of uplift in Middle Silurian time that resulted in extensive erosion of the carbonate platform to the east and concomitant deposition of dolomitic siltstone turbidites in the Kechika Trough. During the marine transgression minor amounts of barite were deposited.

DEVONIAN

The Silurian siltstone unit is unconformably to disconformably overlain by Devonian shale, siltstone, and limestone. With the exception of limestone and the more siliceous shale facies, these rocks are recessive and poorly exposed. In many areas erosion has completely removed the Devonian succession. The most complete Devonian sections occur in overturned synclinoria where they have been preserved beneath overriding thrust plates of older, more resistant strata. Under such a stress regime the incompetent Devonian rocks tend to coalesce into tight isoclinal folds and develop a pervasive axial plane cleavage. These features mask original stratigraphic thicknesses and make recognition of lateral and vertical facies changes difficult. Despite the structural complexity of the Devonian section, an attempt has been made to divide the succession into sedimentary facies and these are described in Table 1.

The distribution of sedimentary facies in the Akie River area suggests that in Early Devonian time the shale basin consisted of two parallel troughs separated by a chain of shallow water carbonate reefs (Fig. 15). The reefs, which are typically composed of an upper and lower unit of medium to thick-bedded limestone containing coral, shell, and crinoid detritus separated by an intermediate unit of shaly thin-bedded argillaceous limestone, appear to have grown on the uplifted edges of tilted fault blocks. The limestone facies (D_{ls}) is thickest along this edge, grading abruptly to the west into a sequence of limestone turbidites, reef front breccias, and pelagic black shale (D_{lt}). The black shales contain Lower Devonian (Pragian) graptolite assemblages. The limestone turbidites grade laterally and vertically into dark grey argillaceous siltstone and sandstone (D_{sl}) containing shell and coral detritus and blue-grey-weathering laminated silty shale (D_{ss}) with orange-weathering calcarenite interbeds that are interpreted to be distal turbidites. These proximal to distal turbidites define several submarine fans within the western shale belt which probably emanated from submarine canyons incised into a steep westward dipping slope. The crest of this slope was probably marked by a northwest-trending fault scarp or hinge zone that was periodically reactivated during Early to Middle Devonian time thus triggering debris flows into the shale basin. Secondary rifts, parallel to the main trend, also occur within the main basin of deposition. These were probably related to development of small-scale graben and horst structures which created second and third order basins within the deepest part of the Kechika Trough.

In contrast to the rapid shale-out observed on the west side of the carbonate reef, on the east the limestone facies thins gradually and grades into a progressively deeper water shale facies. This suggests a gentle paleoslope on the east side of the carbonate reef during Early to Middle Devonian time.

Proximal turbidite facies also occur in the basal part of the Devonian section on the east side of the eastern shale belt. This suggests the west-facing slope of the eastern shale belt, which may have been located immediately adjacent to the main carbonate platform, was also steep. However, in contrast to the western shale belt, the turbidites in this area are predominantly quartz siltstones, sandstones, and conglomerates (D_{qt}) with interbedded limestone debris flows (D_{lt}) and graptolitic black shales. The composition of these rocks indicate a build-up of shallow water quartz sands along the platform margin during Early Devonian time. Much of this detritus may have been derived from erosion of older (Cambrian ?) quartz-rich rocks exposed east of the carbonate platform. The proportion of quartz relative to the carbonate detritus in the Lower Devonian section increases to the northwest. The quartz-rich rocks of the eastern shale belt may correlate in part with the upper part of the Muncho McConnell Formation (Wokkpash Formation of Taylor and MacKenzie, 1970; unit 6 of Thompson, 1976).

The apparent influx of coarse clastic debris into the shale basin during the latter part of the Early Devonian suggests a possible episode of uplift or marine regression that resulted in exposure and erosion of the carbonate reef. A similar hiatus is recognized in the carbonate platform to the east where the Muncho McConnell Formation and older cratonic rocks were exposed prior to deposition of dolomites of the Stone Formation (Morrow, 1978; Taylor and MacKenzie, 1970).

Lower to Middle Devonian turbidites and shallow water carbonate reefs are conformably overlain by a distinctive unit of rhythmically bedded siliceous rocks (D_{sa}). This unit is resistant, typically blocky to slabby weathering, and consists of medium to thin beds of banded black chert to siliceous argillite and siliceous laminated silty shale to siltstone separated by recessive intervals of carbonaceous black siliceous shale. Soft sediment slump structures are common within these rocks. The siliceous facies varies from 20 to 150 metres in thickness and is host to the major bedded barite and massive sulphide deposits of the Driftpile Creek—Akie River district. The siliceous character of the unit may be due to exhalative activity associated with interbasin rifting during the early stages of a major marine transgression during the Middle to Late Devonian (Fig. 15).

Where the siliceous facies transgresses the carbonate reef-shale basin transition zone, it includes thin interbeds of dark grey, fetid limestone and debris flows which locally contain two-hole crinoid plates and coral fragments. Two-hole crinoids also occur near the top of the upper thick-bedded limestone unit of the carbonate reef suggesting that these two facies are in part correlative and probably early Middle Devonian in age (Morrow, 1978). Roberts (personal communication) reports the occurrence of the earliest Upper Devonian ammonoid *ponticeres* from the top of the siliceous facies at the Cirque property. These rocks are probably in part time-equivalents of the Stone Formation of the carbonate platform.

The siliceous facies and its contained barite deposits are conformably overlain by blue-grey-weathering fissile black shale of probable Late Devonian age. The basal part of this unit, which may exceed 500 metres in thickness in the core of synclinoria of the eastern shale belt, is typically rusty brown weathering and locally contains disseminated pyrite and thin pyrite laminae. Nodular barite also occurs sporadically within the basal part of the black shale unit. These rocks probably correlate in part with Besa River shales (Kidd, 1963; Pelzer, 1966) of the eastern carbonate platform and represent a major marine transgression during Late Devonian to Mississippian time.

STRATIFORM BARITE/SULPHIDE DEPOSITS

The timing of stratiform barite-lead-zinc mineralization in the Kechika Trough coincides with the beginning of a major marine transgression in the Middle to Late Devonian. This metallogenic event is represented in the stratigraphic record by a very siliceous and carbonaceous sequence of shale, argillite, and chert which typically contains laminae of nodular barite and pyrite. Locally, the nodular barite grades into beds of massive laminated barite which may or may not have an associated sulphide facies.

The most significant barite-sulphide deposits, Cirque (MI 94F-8), Mount Alcock, and Elf, are restricted to the western shale belt (Fig. 12). This shale belt may represent muds deposited in the deepest part of the Kechika Trough (Fig. 15), in a more reducing environment that favoured sulphide deposition. Such deposition may have occurred in one or more euxinic, third order basins within the trough. Roberts (1977) has

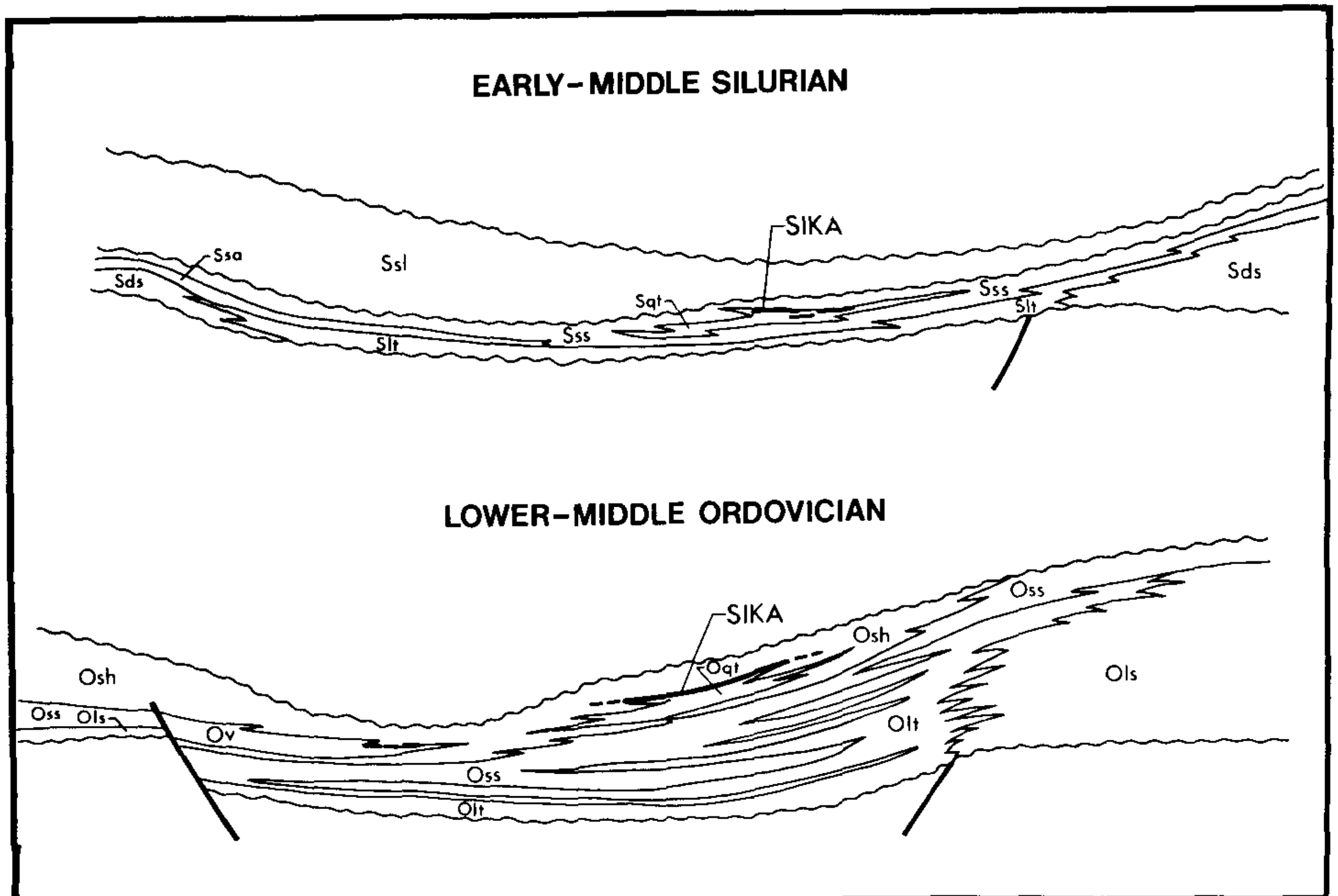

Figure 14. Idealized sections across Akie River shale basin showing possible facies relationships during Ordovician and Silurian time.

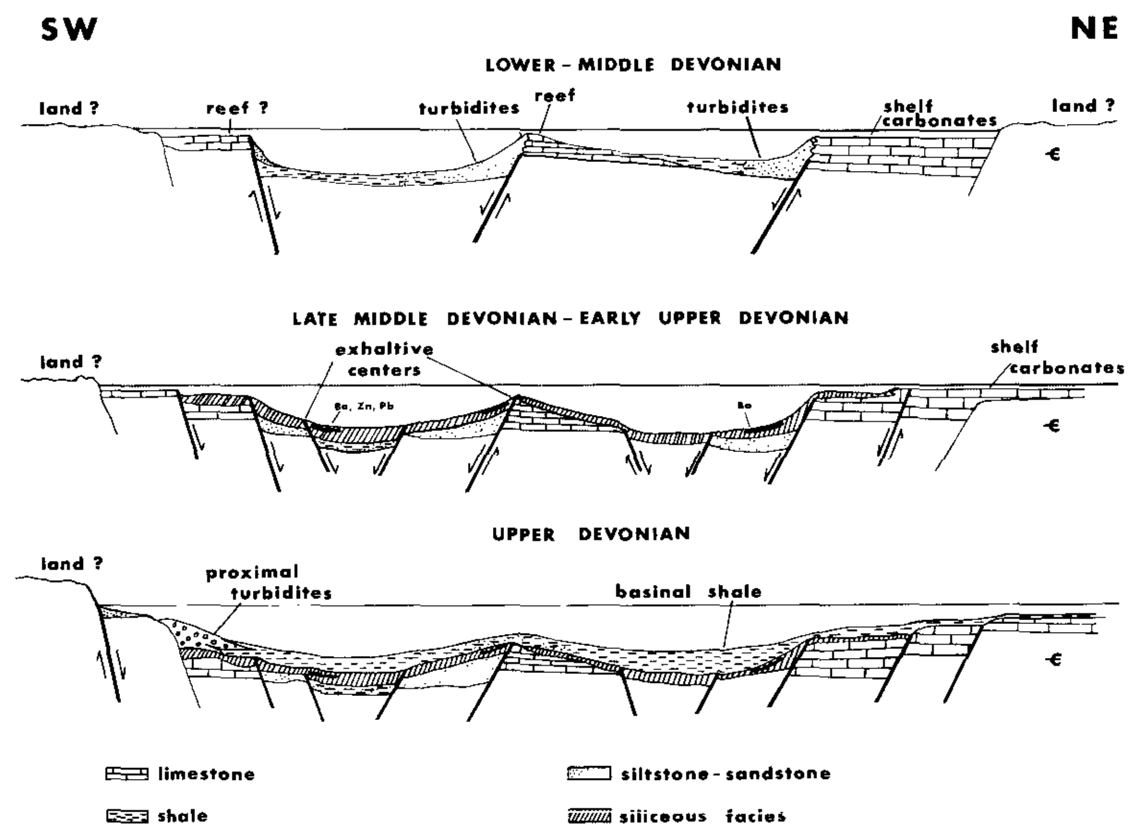

Figure 15. Idealized sections across Akie River shale basin showing sedimentary environments during Early, Middle, and Late Devonian time.

cited anomalous thickening of the siliceous facies as evidence for such a basin at Cirque property. Furthermore, local breccias occur within the mineralized interval at Cirque and may have originated as debris flows that were triggered by movement along nearby synsedimentary faults. The deposit itself, which contains in excess of 30 million tonnes of 10 per cent lead and zinc and 46.65 grams per tonne silver, thickens considerably down dip and to the northwest. The massive bedded barite grades vertically and laterally into laminated massive sulphide toward the northwest, suggesting a feeder vent (Roberts, 1980) in this direction. A similar situation is suggested for the Mount Alcock deposit.

The only major bedded barite occurrence of Devonian age in the eastern shale belt is the Kwadacha deposit (section 16, Fig. 13). It is located immediately north of the southern boundary of Kwadacha Wilderness Park (Fig. 12) and occurs in siliceous argillites and shales overlying Lower Devonian limestone turbidites. The baritic interval, which is up to 30 metres thick, is divisible into a lower unit of interbedded barite and siliceous shale (10 to 15 metres), a middle unit of shale with minor limestone (5 to 10 metres), and an upper unit of medium-bedded grey rusty weathering laminated barite (5 to 10 metres). The limestone contains abundant two-hole crinoid plates, suggesting an early Middle Devonian age. The upper bedded barite unit is overlain by recessive, rusty weathering black shales which locally contain laminae of nodular barite. To date, sulphides have not been found associated with the Kwadacha barite deposit.

DISCUSSION

The stratigraphic setting of shale-hosted barite-sulphide deposits in the Akie River district is strikingly similar to that of Devonian deposits in both the MacMillan Pass area of the Yukon (Carne, 1979) and in West Germany. The deposits, which are clearly syngenetic, typically occur within a siliceous, carbonaceous black argillite or shale facies underlain by or interfingered with proximal to distal turbidites and overlain by deeper water, basinal black shales. This indicates that mineralization coincided with the early stages of a major marine transgression (crustal downwarping ?) which may also have been accompanied by rifting and exhalative activity within the shale basin.

A synsedimentary graben structure and a stockwork feeder zone have been defined at MacMillan Pass (Carne, 1979) but are still unrecognized in the Akie River area. However, in the Akie River area the mineral deposits appear to be associated with northwest-trending interbasin rifts. This rift system was the locus of periodic volcanic and hydrothermal activity from Middle Ordovician to Late Devonian time.

The massive barite-sulphide deposits are wedge to lens-shape and generally lack pelitic interbeds. These features are consistent with Sato's (1972) model of rapid accumulation of dense metalliferous brines in a sea floor depression adjacent to an exhalative vent. A period of alternating pelitic sedimentation and syngenetic to early diagenetic pyrite crystallization accompanied and followed the main episode of barite precipitation and was apparently restricted to the same basin of deposition. It is suggested that the source fluids for both types of mineralization emanated from vents located along the rift zones bounding third order basins. These metalliferous fluids were probably derived by dewatering of underlying shales. Elevated heat flow along the deep-seated rifts may have been the driving mechanism for fluid circulation.

ACKNOWLEDGMENTS

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Roberts, Rob Carne, Charlie Jefferson, Dan Kilby, Mike Cecile, Bob Thompson, Gordon Taylor, and Hugh Gabrielse provided a useful and informative introduction to the area. Kevin Heather, Mike Fournier, and John Mawdsley ably assisted in the field.

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TABLE 1

FACIES DESCRIPTIONS

UPPER DEVONIAN

D_{sh} – Blue grey weathering, fissile black shale. Locally silty and laminated. Rusty brown weathering with minor pyrite and nodular barite near base of unit. Recessive unit.

MIDDLE–UPPER DEVONIAN

D_{sa} – Light bluish grey to dark greenish grey, blocky weathering, rhythmically bedded laminated siliceous argillite, banded chert, siliceous shale, laminated silliceous silty shale, and siltstone. Contains bedded and nodular barite and laminated massive pyrite beds with varying amounts of galena and sphalerite. Thin black fetid limestone and fossiliferous limestone debris flows and turbidites common where unit transgresses shale-carbonate transition zone. Resistant unit.

LOWER–MIDDLE DEVONIAN

D_{ss} – Dark grey weathering, thin-bedded laminated to cross-laminated black silty shale turbidites with minor dark grey argillaceous siltstone and thin orange weathering calcarenite interbeds. Recessive unit.

D_{sl} – Dark grey blocky weathering, thin to medium-bedded laminated and cross-laminated siltstone and sandstone turbidites with thin argillaceous limestone and orange weathering, calcarenite interbeds. Moderately resistant unit.

D_{qt} – Medium grey blocky weathering, medium to thick-bedded quartz siltstone, sandstone, and pebble conglomerate proximal turbidites. Interbedded argillaceous limestone turbidites and graptolitic black shale. Resistant unit.

D_{lt} – Light grey, blocky weathering, medium to thick-bedded limestone turbidites and debris flows. Minor interbedded quartz, siltstone, and graptolitic black shale. Resistant unit.

D_{ls} – Light grey blocky weathering, medium to thick-bedded dark grey argillaceous limestone. Fossiliferous. Resistant unit.

SILURIAN

S_{sl} – Brown to orange, platy to blocky weathering, massive, thick-bedded to thin flaser-bedded dolomitic siltstone. Minor grey laminated limestone and/or dolostone interbeds. Worm burrows and feeding trails common. Resistant unit.

S_{ss} – Dark grey, platy weathering silty shale and siltstone turbidites. Recessive unit.

S_{sa} – Interbedded black chert and grey weathering limestone and/or dolostone turbidites. Slump structures and cherty bands common in limestone. Resistant unit.

TABLE 1 — *Continued*

S_{lt} — Grey, platy weathering, thin-bedded laminated to cross-laminated limestone and dolostone turbidite. Minor shaly interbeds. Resistant unit.

S_{qt} — Orangy grey blocky weathering, massive, thick to medium-bedded dolomitic quartz sandstone and siltstone turbidites. Resistant unit.

S_{ls}/S_{ds} — *Grey to orangy grey, blocky weathering, massive, thick to medium-bedded limestone and/or* dolostone. Resistant unit.

MIDDLE ORDOVICIAN

O_{sh} — Dark to bluish grey weathering black shale. Contains Middle Ordovician graptolite assemblages. Very recessive unit.

O_{qt} — Grey blocky weathering, massive, medium to thick-bedded quartz siltstone, sandstone, and conglomerate, proximal turbidites. Thin black shale interbeds common. Very resistant unit.

O_v — Orange weathering, crystal, lithic, and lapilli tuff with black shale interbeds. Greenish grey blocky weathering microdioritic flows locally underlie tuff horizon. Resistant unit.

LOWER TO MIDDLE ORDOVICIAN

O_{ss} — Light brown to cream weathering, laminated silty shale and dark grey argillaceous siltstone with thin iron oxide streaks. Locally calcareous. Thin cream platy weathering laminated limestone interbeds common. Recessive unit.

O_{lt} — Light grey to yellowish weathering, medium to thin-bedded, laminated to cross-laminated limestone turbidites. Minor dark grey silty shale interbeds.

O_{ls} — *Grey, blocky weathering, medium to thick-bedded massive limestone. Fossiliferous. Resistant* unit.