RESERVOIR ROCKS OF THE LEDUC OILFIELD: DEVONIAN REEFS AND OTHER STRATA NEAR CANMORE AND SASKATCHEWAN CROSSING, ALBERTA

EDMONTON GEOLOGICAL SOCIETY FIELD TRIP

SEPTEMBER 26-28, 1997

LEADERS: WILLEM LANGENBERG, ADAM HEDINGER AND ROBIN WYLLIE

ITINERARY

Saturday, September 27 (leave from hotel at 8:30 AM)
AM STOP1
Grassy Lakes/Spray Lakes Road: Leduc/Nisku/Blue Ridge reef interior section
PM Partial section: Trans Canada at Lac des Arcs
Additional sections in Canmore area
Evening: Slide presentation on Leduc/Nisku/Blue Ridge reefs in Alberta Front Ranges

Sunday, September 28 (leave from hotel at 8:00 AM)
AM STOP 2
Big Hill section and selected outcrops on David Thompson Highway
PM Devon Interpretive Centre

The following handouts are selected pages from a GAC Guidebook:

E.W. Mountjoy and H.H.J. Geldsetzer (1981): Devonian stratigraphy and sedimentation, Southern Rocky Mountains. Field Guides to Geology and Mineral Deposits, Calgary '81, GAC, MAC, CGU, pp.195-224.

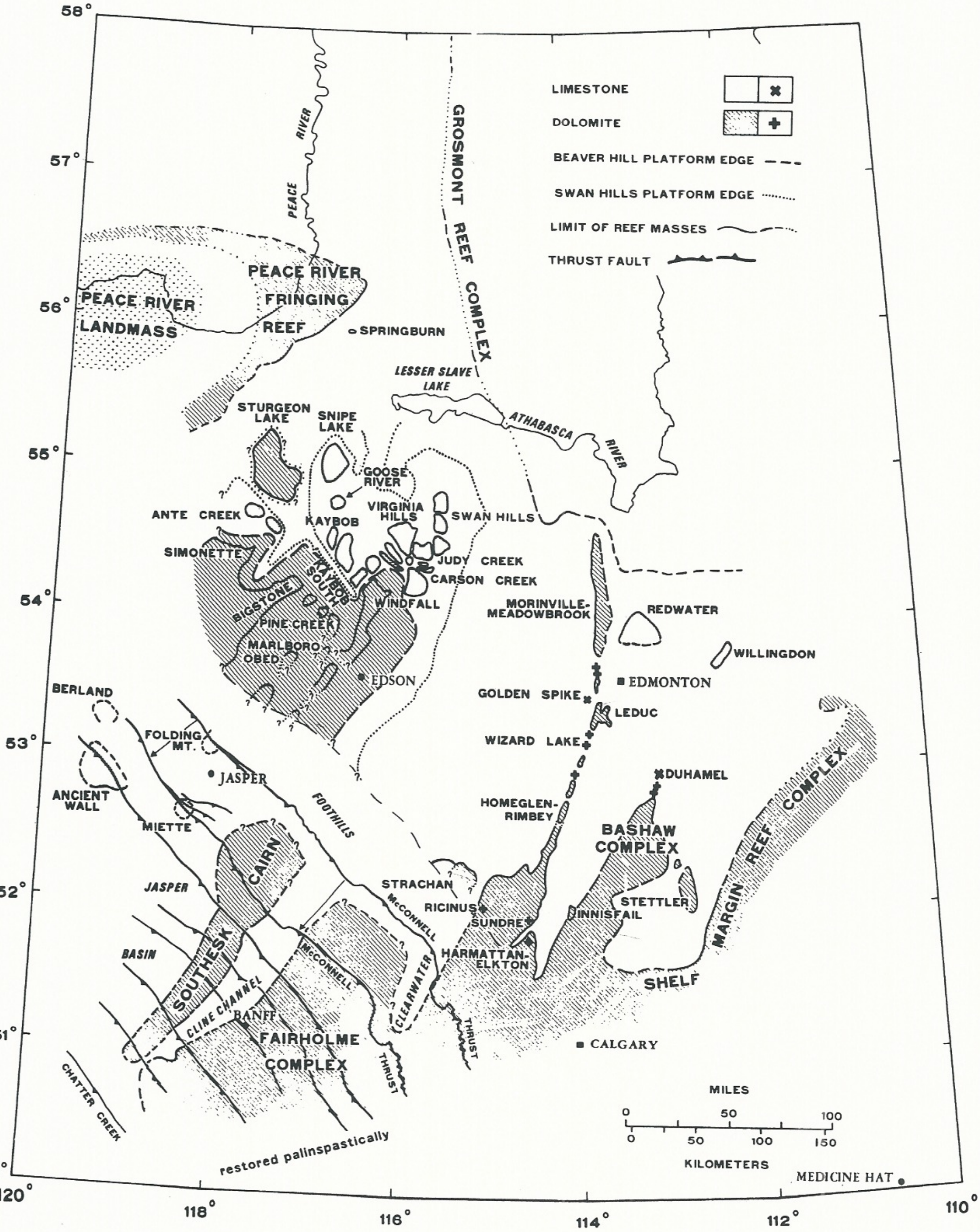


Figure 2. Upper Devonian reef complexes and platforms in southern Alberta. The thrust faulted area in the southwest corner has been palinspastically restored (Mountjoy, 1978).

Upper Devonian Depositional Development

The stratigraphic relationships between the reef-bank facies and the off-reef facies, both in surface outcrops and in the subsurface, are shown on Figure 5.

A carbonate platform (Flume and Maligne Formations) marks the base of the Upper Devonian succession throughout the excursion area and will be seen at most localities. The basal platform developed upward into massive organic buildups (Cairn Formation and Peechee Member of the Southesk Formation) fringed by stromatoporoid-dominated reef-like margins. These carbonate complexes will be studied at Canmore (Stop 1) and the Big Hill section (Stop 3) near the Columbia Icefields. At both locations the buildups are completely dolomitized, unlike the smaller complexes of Ancient Wall and Miette north of Jasper.

An investigation of the Miette Complex near Jasper demonstrates that dolomitization took place during several intervals of moderate to deep burial, presumably related to Mg-rich brines squeezed from adjacent or underlying strata (Mattes and Mountjoy, 1980). Considerable porosity reduction and enhancement occurred early and during several stages of burial (Walls *et al.*, 1979).

Dark basin shales of Early Frasnian which are laterally equivalent to at least the lower two-thirds of the organic buildups accumulated between the reef complexes in a restricted anoxic marine environment. They are represented by the Perdrix Formation in surface outcrop and by the Duvernay Formation in the subsurface. More open-marine and shallow-water conditions prevailed during the deposition of the overlying Upper Frasnian shales and shaly carbonates of the Mount Hawk Formation (Ireton Formation in the subsurface). The terrigenous components of these sediments were derived from an easterly source (Oliver and Cowper, 1963; Sheasby, 1971). These Upper Frasnian sediments filled most of the basinal areas and can be shown to interfinger with basinward prograding carbonate banks of the Upper Southesk Formation (Grotto, Arcs and Ronde Members) laterally equivalent to most of the Nisku Formation in the subsurface. The basinal succession will be examined in the Cline Channel at Cline River (Stop 2) and along the southeast margin of the Jasper Basin at Cold Sulphur Spring (Stop 4), on Cinquefoil Mountain (Stop 6) and at the mouth of the Fiddle River Gorge (Stop 5). A "Nisku"-type coral mud mound with *Disphyllum* corals and stromatactis cavities will be studied on the Cinquefoil Mountain section.

The stratigraphic relationships between the carbonate buildups and the basinal succession have been examined at the margins of the Miette and Ancient Wall reef complexes (Mountjoy, 1965, 1967; Mountjoy and MacKenzie, 1973), along the northwest margin of the Cairn - Southesk Complex (Mountjoy, 1978) and along the northwestern margin of the Fairholme Complex (Harrison and Jackson, 1978; Workum, 1978).

At the Ancient Wall Complex, debris beds in the Mount Hawk Formation indicate that most of the Peechee Member accumulated during deposition of the basal Mount Hawk Formation (Mountjoy, 1978) whereas at the margin of the Fairholme Complex, Harrison and Jackson (1978, p. 44) correlate the Peechee Member with both the Perdrix and the Mount Hawk Formations, and Workum (1978, p. 81) regards the Peechee Member as an equivalent of the Ireton Formation which in turn is shown to be a correlative of the Perdrix Formation.

Unfortunately, for most of the basin fill it is very difficult at present to establish precise correlations because of the lack of sufficient fossils and marker beds. Establishing correlations is

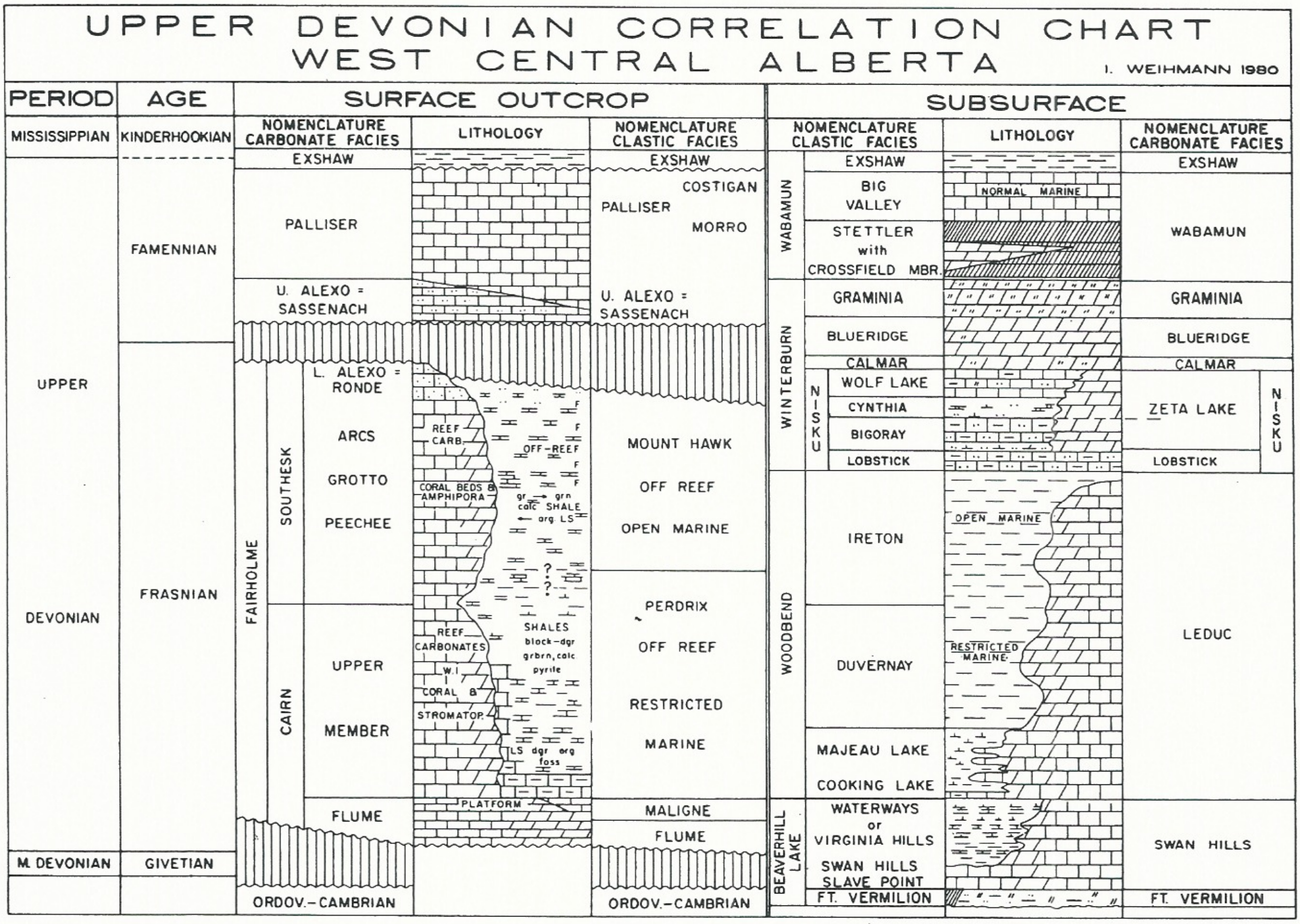
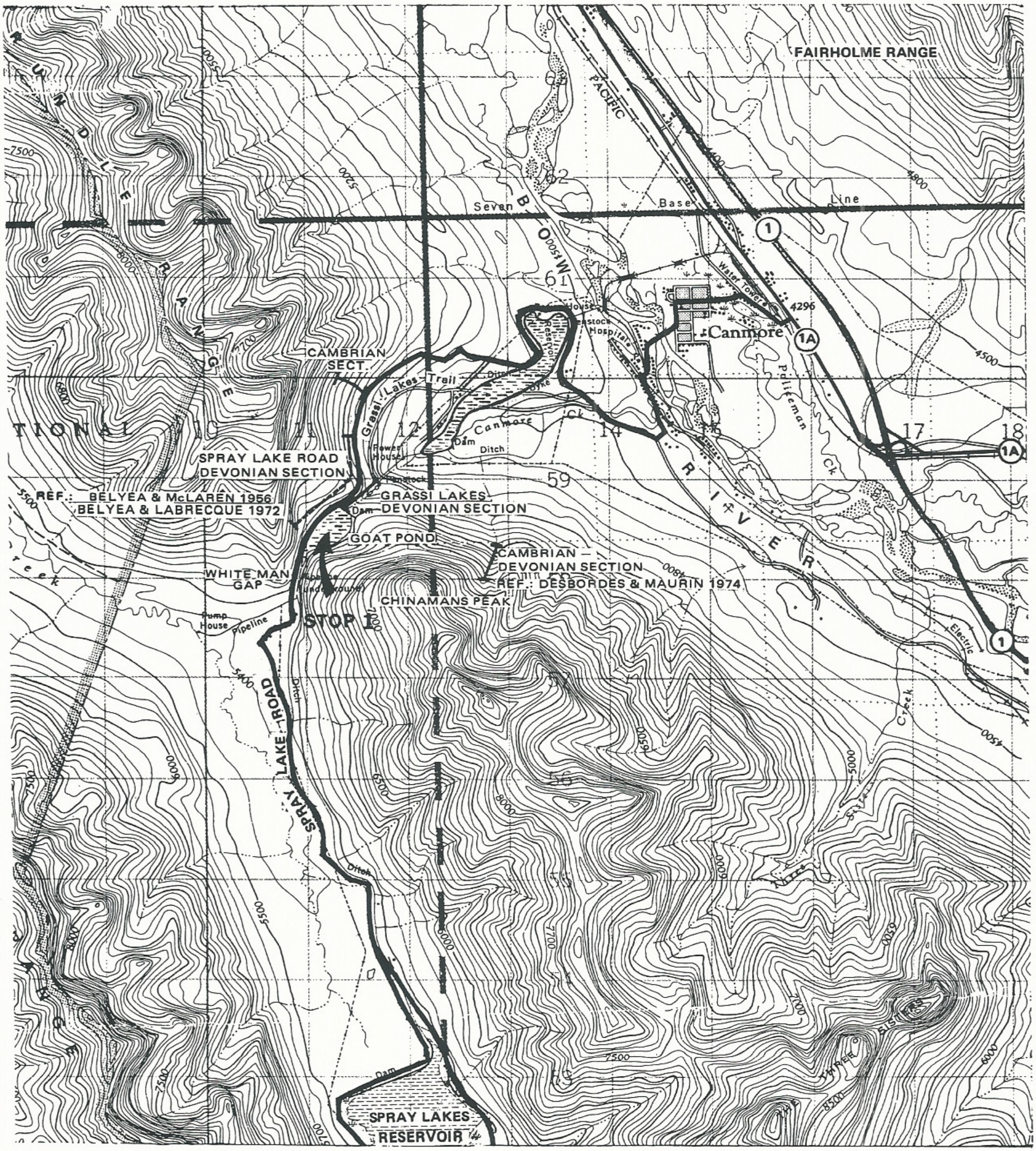


Figure 5. Upper Devonian correlation chart, west central Alberta (Weihmann, *in* Downey and Smith, 1980).



LOCATION MAP
1:50,000
CANMORE, ALBERTA
82 0/3 WEST

1 MILE

1 KM

Figure 7. Location map of Stop 1 "Grassi Lakes-White Man Gap" near Canmore (Weihmann, 1979).

From the Lac des Arcs to Banff the Bow Valley follows the Mount Allan Syncline, made up of a sequence of weak Mesozoic rocks in the upper part of the McConnell Thrust Plate. The Mesozoic rocks are overturned to the northeast beneath the Rundle Thrust Plate.

STOP 1: Grassi Lakes - White Man Gap, Canmore, Alberta

Location: After crossing the Bow River on the Trans Canada Highway, turn into Highway 1A to Canmore, cross the centre of town, turn left onto 8th Avenue, cross the Bow River and railway tracks and follow paved road to Spray Lakes. Turn left at sign "Entrance to Spray Residential and Plant Area". Follow road for about 0.3 km and park within the right of way of the power lines. Turn right into the forest and walk 1.5 km along Grassi Lake Trail to the Devonian reef outcrops (Fig. 7).

Description: The Devonian rocks form part of a southwest-dipping thrust plate above the Rundle Thrust Fault (Fig. 8). The thrust plate overrides the Mount Allan Syncline which coincides with the Bow River Valley in this area and is underlain mostly by Jurassic - Cretaceous sandstone and coal-bearing mudstone of the Kootenay Formation steeply overturned on the southwest side beneath the Rundle Thrust.

The Devonian section lies within and close to the northern margin of the Fairholme Reef Complex (Fig. 2) and displays a very thick development of stromatoporoid banks and bioherms.

The outcrops illustrate various facies within the Fairholme Group. The contact with underlying Middle Devonian and Cambrian rocks can be examined in poorly accessible gullies nearby.

Cambrian. Grey limestone of the Middle Cambrian Pika Formation underlies yellow to pink silty dolomite and limestone of the Arctomys Formation in a steep dry gully a few hundred metres east of the Fairholme outcrops. The Middle Cambrian is overlain by pisolitic dolomites of the Upper Cambrian Lynx Group.

Most of these beds appear to have been formed under intertidal conditions in a hot climate, comparable to the modern Sabkha environment. Finely laminated and mottled dolomites as well as stromatolites, possibly including the pisolites of the Lynx Group originated in extensive algal flats. Periodic evaporitic conditions are indicated by salt casts and a typical greenish coating on bedding planes in the Arctomys Formation. The Cambrian units have been extensively described and reviewed by Aitken (1967, 1968).

Middle Devonian. The Cambrian beds are in contact with the Devonian Yahatinda Formation which is at least 17 m thick and consists of thinly bedded and banded dolomite and may include layers of collapse breccia. The Yahatinda sediments fill topographic depressions on the Cambrian erosion surface and may be a distant equivalent of the Elk Point Group.

The sub-Devonian unconformity and the overlying Yahatinda Formation were discussed in detail by Aitken (1966).

Upper Devonian. The Fairholme Group of Frasnian age and the Sassenach and Palliser Formations of Famennian age make up the Upper Devonian. The sedimentology of the Cairn and Southesk Formations of the Fairholme Group is the object of Stop 1. Panoramic views and sketches of the distribution of depositional units for both formatins are shown on Figures 9 to 12. Lithologic details and faunal aspects of the section are illustrated in Figure 13.

The Cairn was divided by Belyea and McLaren (1956) into an informal basal dolomite member and an overlying black, organic dolomite member. The basal dolomite member is 30 m thick and consists of interbedded light and dark grey weathering dolomite, silty and argillaceous towards the base, and variably laminated. Bands and lenses of chert are common in the upper part. *Atrypa, Amphipora* and small stromatoporoids have been reported. This unit is the approximate equivalent of the Flume Formation. The lowest major depositional unit (No. 1) of the outcrop section may belong to this basal dolomite member of the Cairn Formation (Figs. 10 and 13).

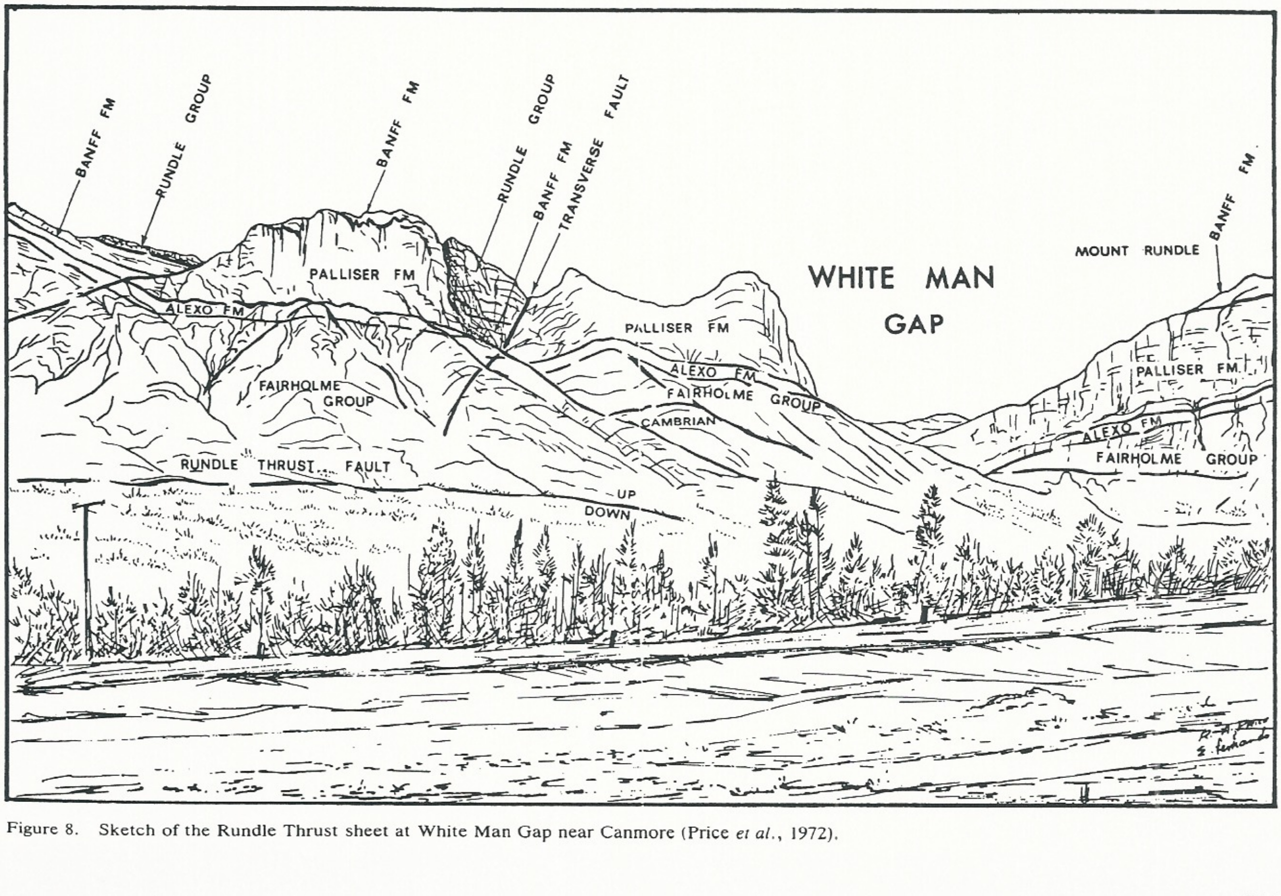


Figure 8. Sketch of the Rundle Thrust sheet at White Man Gap near Canmore (Price *et al.*, 1972).

Black Reef (McLaren, 1955)

The black organic dolomite member, 160 m thick, is composed predominantly of dark grey to black dolomite, medium bedded to massive with alternations of massive beds and laminated beds.

The laminated beds contain a few *Amphipora* or small stromatoporoids and probably represent the shallow lagoonal and part of the coral -*Amphipora* biogenic bank facies (major depositional units 2 and 8 respectively of Figs. 10 and 13).

In contrast, the massive beds contain an abundant but restricted fauna consisting predominantly of branching and massive stromatoporoids, tabulate corals, and rarely, of scattered brachiopods and gastropods; some beds are extremely rich in *Amphipora,* which are mostly flat-lying. At least three thick stromatoporoid-rich biostromes can be traced by eye from the road northward across the mountainside. For the most part, they seem to be vaguely bedded. Relatively few stromatoporoids are in growth position, but they do not seem to have been rounded or rolled any great distance. Rather, they appear to be close to growth position in an environment of considerable turbulence. The surface of some massive units is somewhat undulating. Centres of many massive stromatoporoids tend to be leached and form large vugs on the outcrop surrounded by light grey dolomite ghosts of the original stromatoporoid structure, a spectacular contrast to the almost black matrix. The top of the Cairn is taken at a thin, black, argillaceous, fetid dolomite containing *Amphipora,* stromatoporoids and tabulate corals.

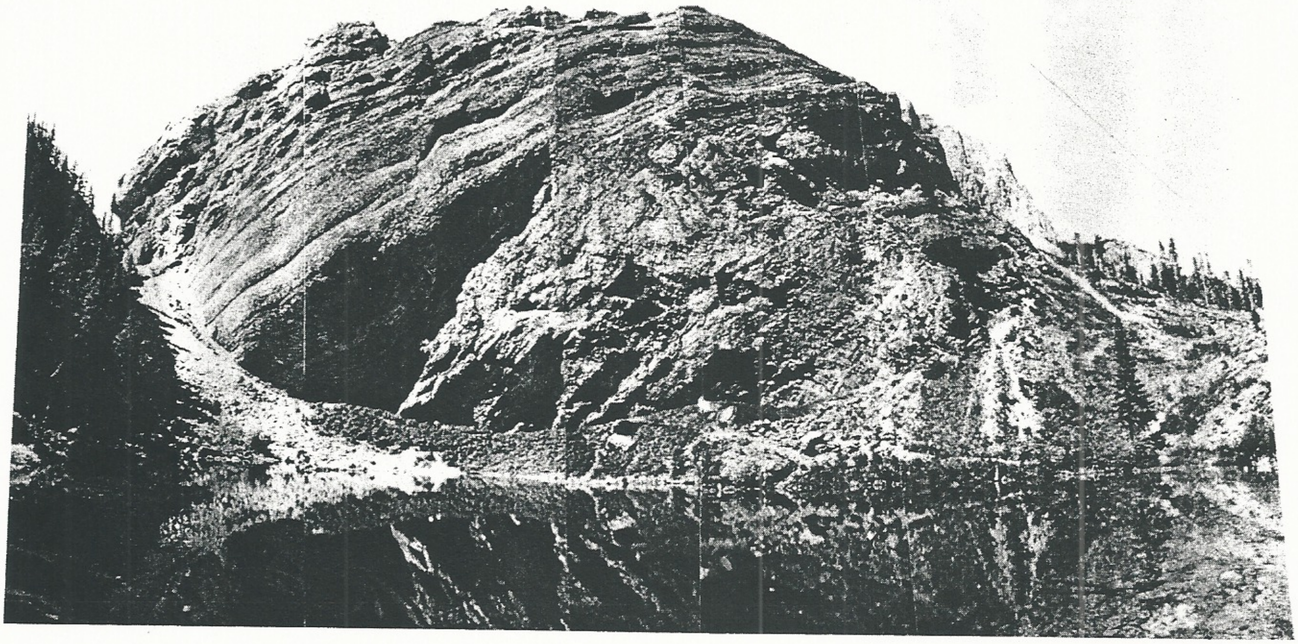


Figure 9. Panoramic photograph, Cairn Formation, Grassi Lakes (Weihmann, 1979).

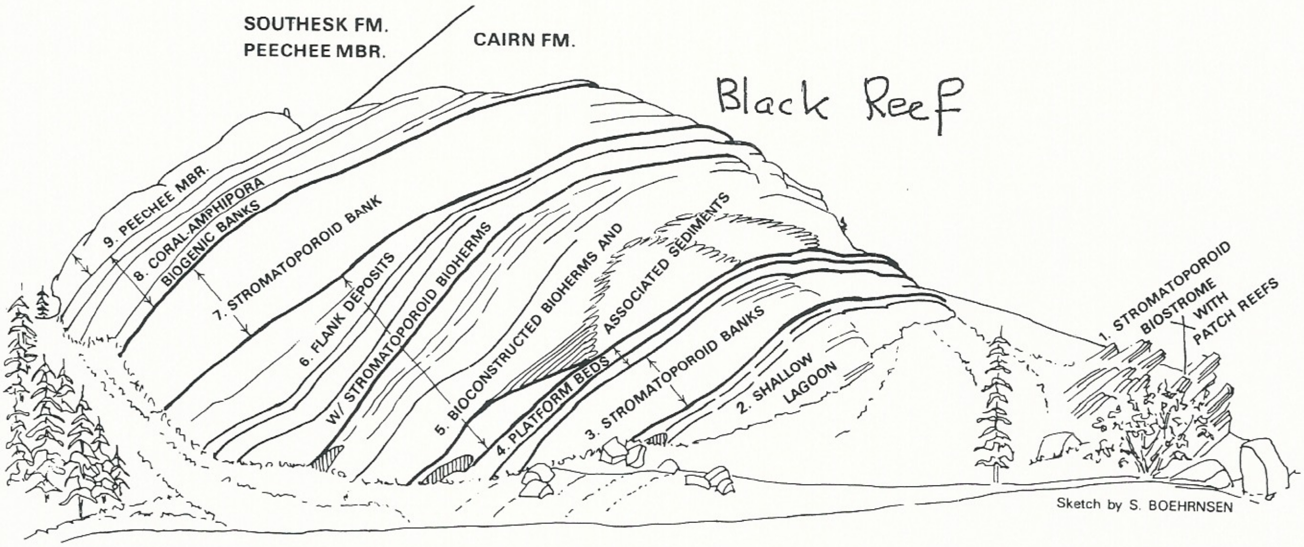


Figure 10. Cairn Formation - View from upper Grassi Lake showing major depositional units. Interpretation by O.G. Burrowes and G.E. Vecsey (Weihmann, 1979).

Figure 11. Panoramic photograph, Southesk Formation, Grassi Lakes (Weihmann, 1979).

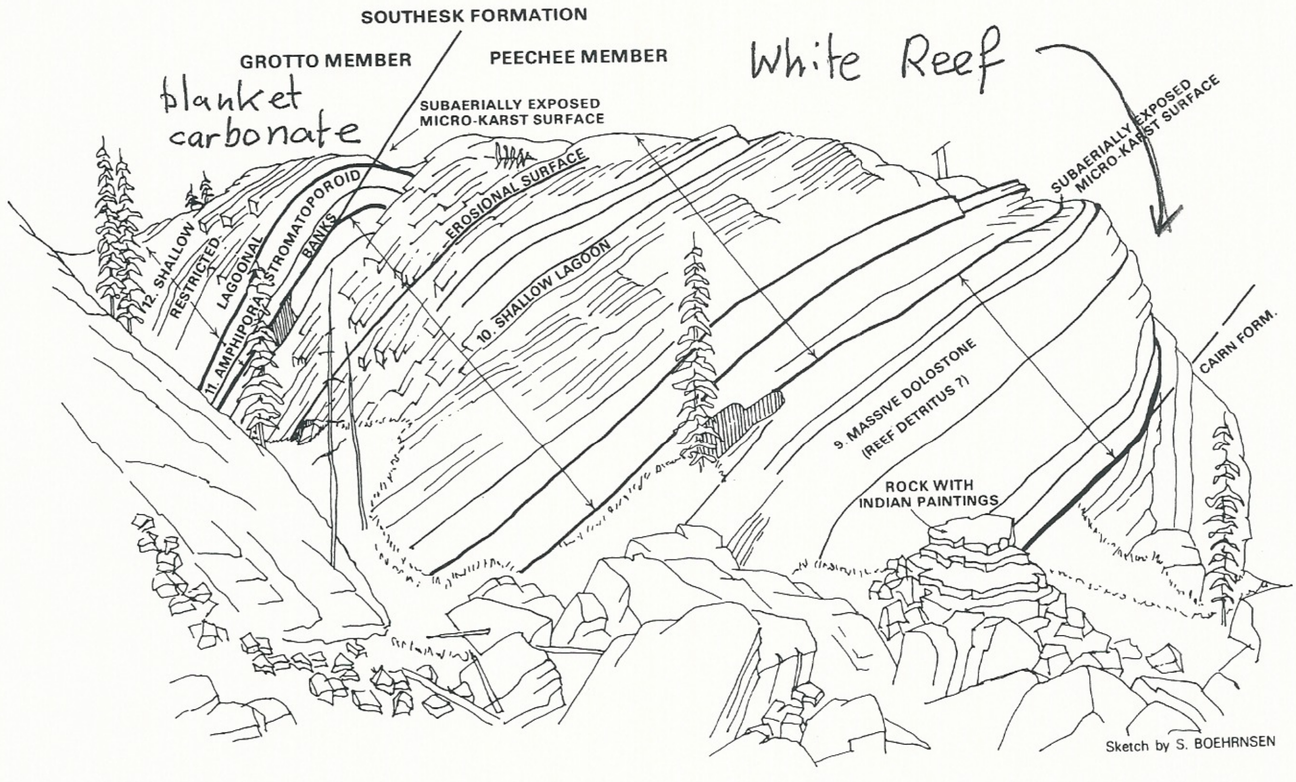


Figure 12. Southesk Formation - Northwest view from behind rock with Indian paintings, showing major depositional units. Interpretation by O.G. Burrowes and G.E. Vecsey (Weihmann, 1979).

UPPER DEVONIAN

CAIRN - SOUTHESK SECTION
GRASSI LAKES - WHITE MAN GAP

BY : O.G. BURROWES , GULF CAN. RES. INC.

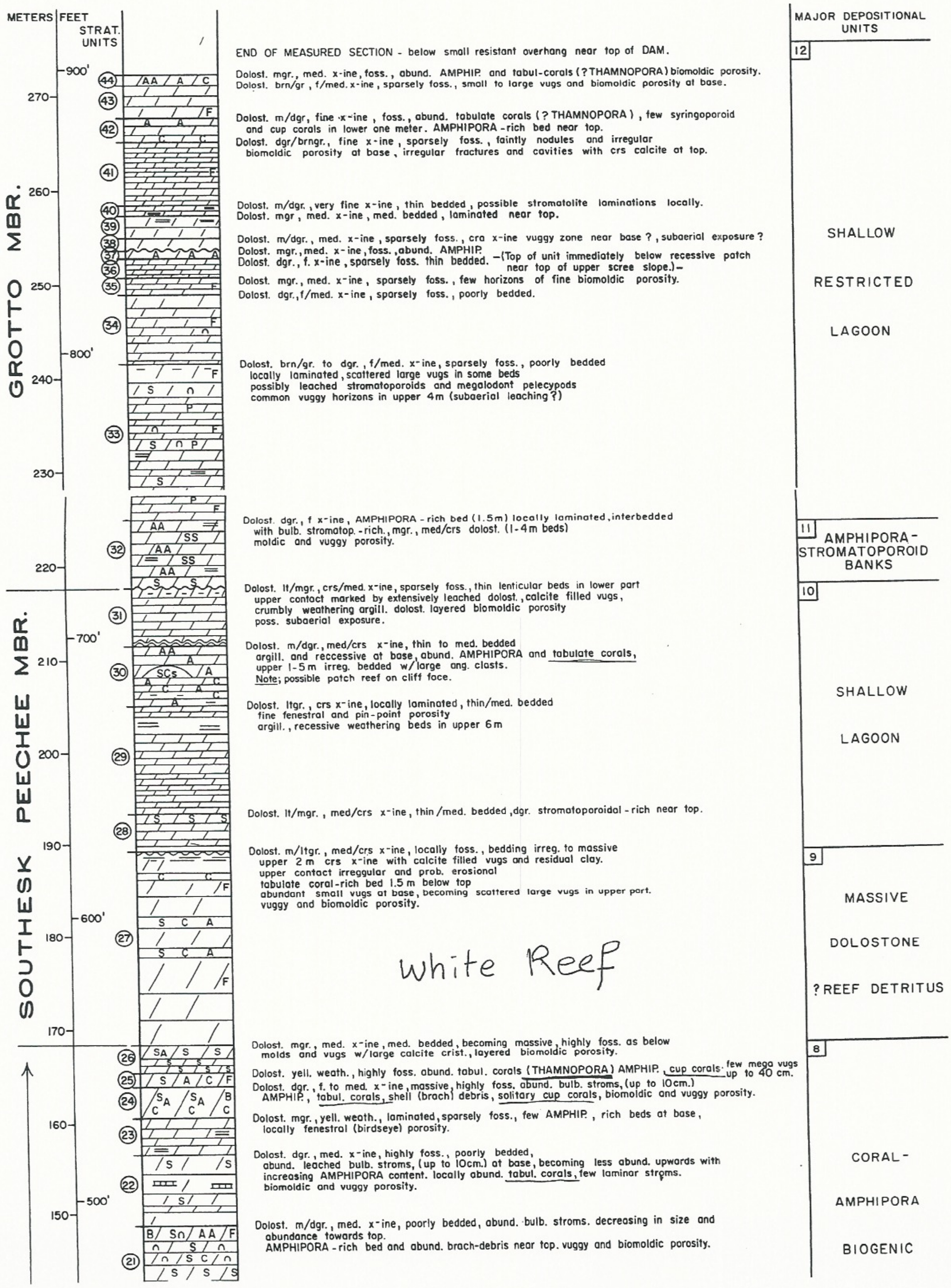
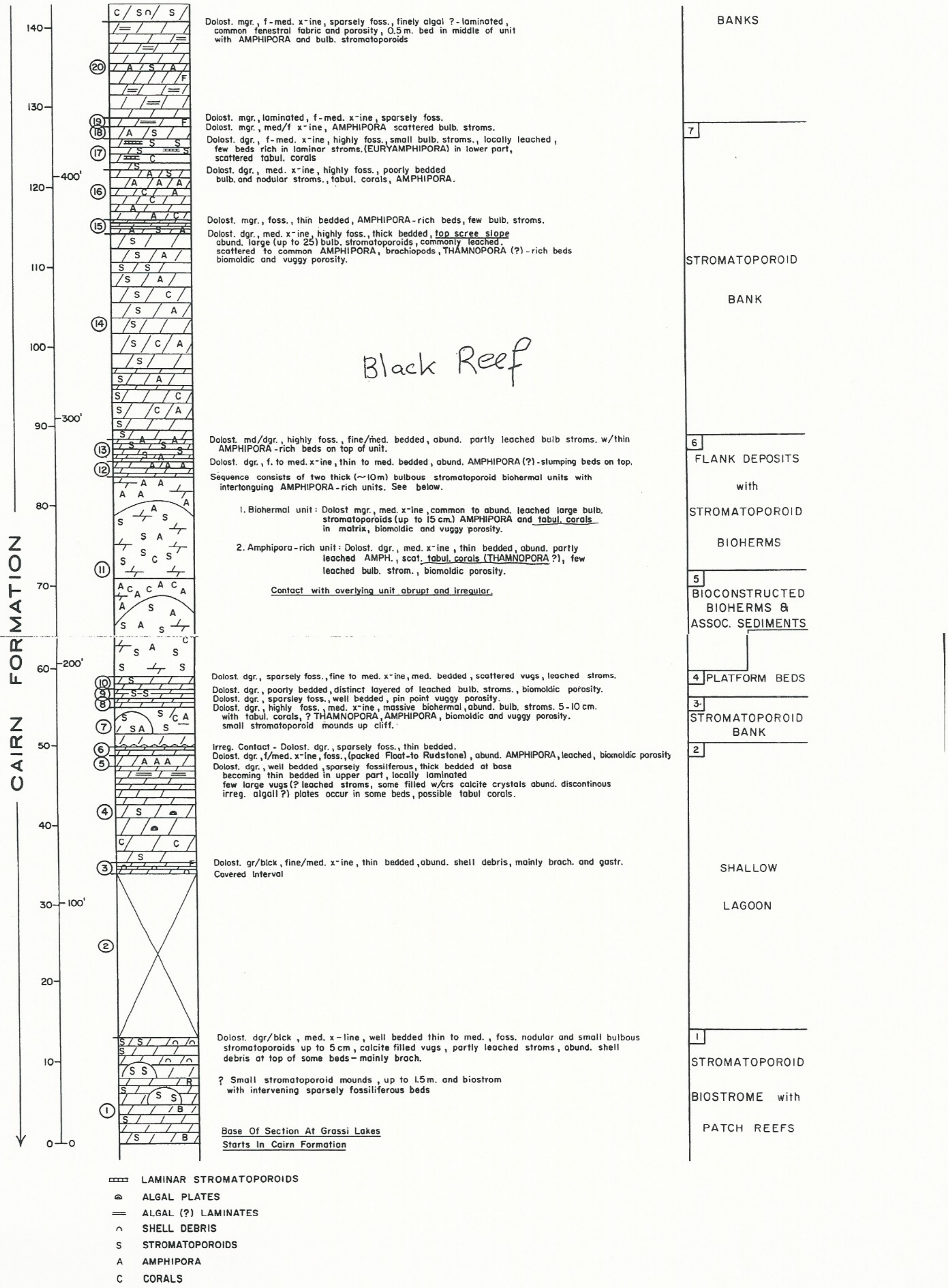


Figure 13. Upper Devonian Cairn - Southesk Section, Grassi Lakes - White Man Gap (Burrowes, *in* Weihmann, 1979).

Figure 13. (Continued)



The lithology of major depositional units 3, 5, 6 and 7 fits the above description. The massive stromatoporoid banks and bioherms of these units indicate the culmination of reef development at this locality.

White Reef

The Cairn Formation is overlain by the Peechee Member of the Southesk Formation. The Peechee Member is about 50 m thick at this locality. The lower part consists of beds of light grey, slightly argillaceous, fetid, medium- to coarse-grained, massive dolomite and black, slightly argillaceous, medium-grained dolomite containing corals and gastropods. Dark lenses are present on the hillside, but relationships of dark and light lenses and layers are not as evident as they are on the "Big Hill" section (Stop 3 of this excursion).

The upper part of the Peechee Member consists of massive, light grey, coarse-grained, porous dolomite. Most beds show large cavities on the weathered surface. The upper surface which is in contact with the Grotto Member of the Southesk Formation is somewhat undulatory and irregular.

The environment of deposition of the lower part has been interpreted as massive reef detritus whereas the upper part may represent shallow lagoonal conditions.

The Grotto Member of the Southesk Formation consists of variable alternations of grey, dark grey, and black, medium- to coarse-grained dolomite, mostly medium- to thick-bedded, but in part massive. Most of the member is fetid; some but not all of the units are characterized by vugs and cavities on the weathered surface. Organic remains are rare except for *Amphipora* and coral traces near the base and abundant *Amphipora* and tabulate corals in the upper few feet. The contact with the overlying Arcs Member is sharp and can be seen a few metres above the road a short distance below the dam.

The Grotto Member at the Grassi Lakes locality is about 60 m thick and consists of shallow, restricted lagoonal sediments with a thin *Amphipora*-stromatoporoid bank at the base. Exposures above the last shown outcrops of the Grotto Member (Fig. 11) are poor.

The descriptions of the overlying Arcs Member, the Alexo/Sassenach Formation and the Palliser Formation (Belyea and Labrecque, 1972) complete the Upper Devonian of the Grassi Lakes - White Man Gap area.

The Arcs Member is predominantly light grey, thick bedded to massive, some massive beds having vague bedding planes. Most of the massive beds have large vugs on the weathered surface. A few *Amphipora* occur near the base. Along the road near the dam, one massive bed contains an abundant dolomitized shelly fauna, probably of pelecypods.

The Alexo/Sassenach Formation is not exposed along the road but was visible in the river bed before the river was dammed. On the mountain, the formation is poorly exposed in several gullies and thicknesses are unreliable. It is divided into two members here. The basal 7 m of the lower member is formed predominantly of sandstone, pale greenish grey, fine grained, quartzose, dolomitic, and pyritic, varying to sandy dolomite and quartz siltstone, some of which has a matrix of dolomite and clay minerals. It weathers pale yellowish brown and locally to reddish brown. It is overlain by a sequence of silty dolomite and limestone with interbedded siltstone and shale layers; bedding is thin to medium and laminated dolomites are common. Small slump structures and breccias occur in the limestones. The upper member is predominantly dolomite, coarser and with thicker bedding than the lower member, but is also strongly laminated. It is commonly silty with intercalated siltstone layers. Slumping and current structures are present. The member is unfossiliferous and probably represents a period of marine recession, possibly corresponding to modern shallow-water, intertidal and/or supratidal environments.

The Alexo/Sassenach grades upward into the Palliser Formation which forms the sheer cliff that rises to the mountain top at this point. The basal beds can be examined along the road and up the hillside in the vicinity of the gate to the Forest Reserve. They consist of massive-bedded, brown, light grey weathering limestone with typical light brownish weathering dolomite mottling. A few silty layers occur in the lower part. The limestones are predominantly cryptocrystalline to microcrystalline, commonly containing bahamiths, lumps consisting of locally derived, cemented carbonate particles (Beales, 1956). Most of the massive limestone is covered by forest growth but the upper part is visible in a gully above an old lumber camp on the dip slope of the mountain. The upper beds contain the fauna typical of the Palliser throughout the Banff area.

The Palliser is abruptly overlain by the black shale and overlying dark-yellowish-orange weathering siltstone of the Exshaw Formation.

DAY 1 (P.M.) CANMORE TO CLINE RIVER

The Trans Canada Highway enters the Banff National Park and by-passes the town of Banff on the north side. Just west of Banff an excellent panorama opens up at Vermilion Lakes. A natural cross section through the western part of the Front Ranges shows from east to west the Rundle Thrust Plate, the Sulphur Mountain Thrust Plate and the Bourgeau Thrust Plate.

The Upper Devonian Fairholme Group and local remnants of the Middle Devonian Yahatinda Formation occur in all three thrust sheets, but resting on progressively younger rocks to the west; the underlying rocks are Middle Cambrian Arctomys - Lynx in the Rundle Thrust Plate, Upper Cambrian Mistaya to Lower Ordovician Survey Peak in the Sulphur Mountain Thrust Plate and 370 m of the Lower Ordovician Survey Peak in the Bourgeau Thrust Plate.

At the North Saskatchewan River, about 100 km to the northwest, a thick Ordovician section is preserved beneath Upper Devonian rocks, the section reaching 1234 m on Mount Wilson.

The magnitude of erosional truncation beneath the sub-Devonian unconformity is also evident at the latitudes of Jasper (Stops 4, 5 and 6) where the same eastward thinning of the Lower Paleozoic strata can be observed. This erosional thinning to the east is further magnified by the depositional eastward thinning of the Ordovician and Cambrian units.

The Trans Canada Highway continues to follow the valley of the Bow River which cuts across the Bourgeau Thrust Plate at a low angle and crosses the boundary with the Main Ranges near Castle Mountain (formerly Mount Eisenhower). The Main Ranges are characterized by relatively flat-lying beds and broad, open folds. Cambrian and Ordovician strata form the dominant outcrops along the mountain slopes, with clastics of the Hadrynian Miette Group frequently exposed along the valley floor and the lower mountain slopes.

Towards the northwest the Bow River Valley follows the axis of a broad, faulted, anticlinal structure. The highway route to Lake

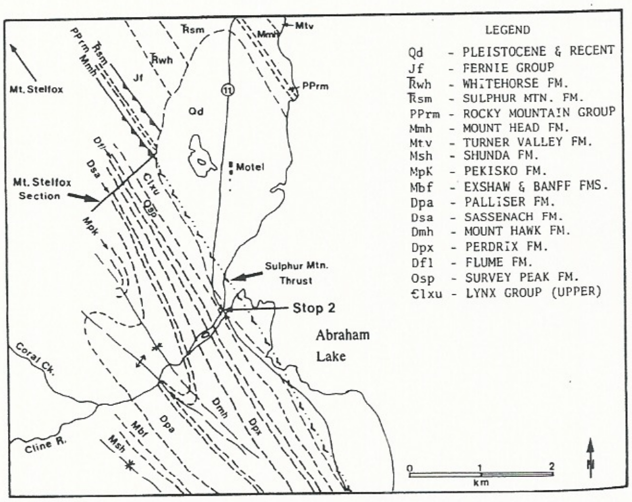


Figure 14. Location map and geology of Stop 2 "Cline River" on the David Thompson Highway.