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STRATIGRAPHY AND TECTONIC SETTING OF THE ARCHIBALD AND ELISE FORMATIONS, ROSSLAND GROUP, BEAVER CREEK AREA, SOUTHEASTERN BRITISH COLUMBIA (82F/4E)

By Kathryn P.E. Andrew, Trygve Höy and John Drobe

KEYWORDS: Regional geology, Rossland Group, Archibald Formation, Elise Formation, Hall Formation, conglomerate, turbidite, submarine fan, growth faults, volcanism, Champion Lake fault, Beaver Creek fault.

INTRODUCTION

The 1989 Rossland project focused on 1:20 000 regional mapping of the Rossland Group and study of selected mineral deposits in the Rossland–Trail east-half and Salmo west-half map areas (Figure 1-2-1). The mapping complements previous work in the Nelson map area to the northeast (Höy and Andrew; 1988, 1989a, b). The aim of the Rossland project is to develop a better understanding of the stratigraphic and tectonic setting of the Rossland Group and the controls of gold and silver mineralization. The project includes systematic whole-rock and trace element analyses of volcanic rocks, and fluid inclusion, stable and radiogenic isotope studies of mineral occurrences. This is the third year of the project and completion of mapping in 1990 is planned to cover the Rossland camp and south to the U.S. border.

This report deals primarily with overall distribution of the Archibald and Elise formations and facies changes within them. The geology of Rossland Group rocks in the Salmo area to the east is described in Höy and Andrew (1990a, b).

Regional mapping in the Rossland–Trail map area (Little 1960, 1962, 1982) included the Beaver Creek area (Figure 1-2-1). A geochemical and petrological study of volcanic rocks in the Rossland Group has been completed by Beddoe-Stephens and Lambert (1981) and Beddoe-Stephens (1982). The Beaver Creek area has been mapped most recently by Fitzpatrick (1985). The area to the south of Beaver Creek, in the vicinity of the Waneta fault zone, is currently being mapped as part of a Ph.D. thesis by J. Einerson, University of Calgary.

STRATIGRAPHY

The Rossland Group in the Beaver Creek area comprises a basal succession of fine and coarse-grained clastic rocks of the Archibald Formation, volcanic and epiclastic rocks of the Elise Formation, and overlying fine-grained clastic rocks of the Hall Formation (Figure 1-2-2). These rocks are Early Jurassic in age, bracketed by Sinemurian fossils in the Archibald (Frebold and Tipper, 1970; Tipper, 1984) and Pleinsbachian and Toarcian macrofossils in the Hall (Frebold and Little, 1962; Tipper, 1984). The Rossland Group is intruded by numerous small stocks that are probably correlative with either the Middle to Late Jurassic Bonnington or Trail plutons (Ghosh, 1986) and also by many diorite or rhyolite dikes and Coryell alkalic intrusions of Eocene age.

ARCHIBALD FORMATION

The Archibald Formation, named after exposures in Archibald Creek southwest of Salmo, is the lowermost unit of the Rossland Group. It generally comprises a succession of interbedded siltstones, sandstones and argillites with prominent sections of interbedded coarse conglomerate. The formation is exposed as a west-facing homoclinal panel on the slopes northwest of Montrose and Fruitvale and in the core of an anticline on the slopes opposite Marsh and Hudu creeks. In the Salmo area, it is exposed in the limbs of the Mount Kelly syncline and as east and west-facing panels east of Archibald Creek (Höy and Andrew, 1990a, this volume).

Previously referred to as "the Sinemurian beds", the Archibald Formation has yielded several macrofossil collections with *Arnioceras* indicating both early and late Sinemurian ages (Little, 1960; 1964; 1982; Tipper, 1984). Several new ammonite localities discovered during the 1989 season may further constrain the age of the formation. The base of the formation is not exposed; it is cut by either faults or by Middle Jurassic intrusions.

Detailed stratigraphic sections of the Archibald Formation in the Trail–Salmo–Nelson map areas are shown in Figure 1-2-3. The total exposed thickness of the formation varies from 825 to 2550 metres (Figure 1-2-4). It is thickest in the Mount Kelly–Archibald Creek–Gillian Creek sections and thins substantially to the west near Fruitvale and to the north in the limbs of the Erie Creek anticline (Höy and Andrew, 1989b). The oldest exposed rocks in the formation, the basal part of the Mount Kelly section, are dark grey to black, rusty weathering argillite and minor siltstone over 600 metres thick. They are massive to finely laminated. An interbedded sequence of thick-bedded, graded wacke, siltstone and silty argillite comprises the upper 1500 metres of the Mount Kelly section. Graded beds, sharp basal contacts and basal scours suggest that the sequence consists largely of turbidites (Plate 1-2-1). Crossbedding is seen only rarely (Plate 1-2-2). A number of augite porphyry sills or flows (?) occur at the top of the section, near the contact with the overlying Elise Formation.

In the Beaver Falls and Copper Creek sections, the lower argillite unit is either missing, not exposed or replaced by a coarser facies (Figure 1-2-3). The Beaver Falls section generally coarsens upward with approximately 540 metres of massive thick-bedded siltstone at the base, overlain by 300 metres of dominantly graded pebble sandstone and 430 metres of chaotic matrix-supported conglomerate and pebble sandstone. The conglomerate is poorly lithified and contains approximately 10 per cent limestone and siltstone clasts

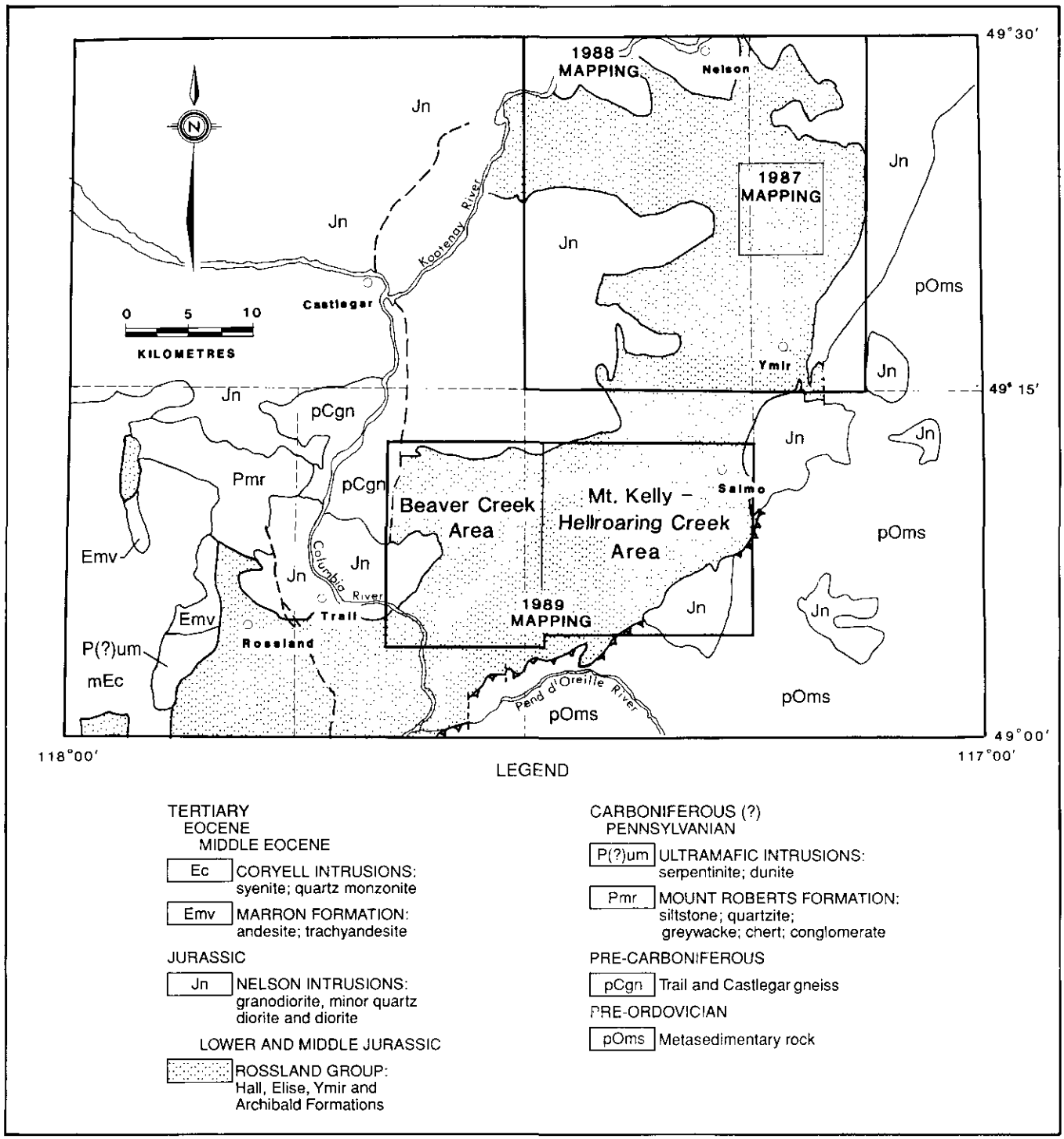


Figure 1-2-1. Location map and main physiographic features, Beaver Creek area, southeastern British Columbia.

(Plate 1-2-3); fossils in the limestone clasts have been identified as Permian, indicating that they are probably derived from the Mount Roberts Formation (Little, 1982). Similar limestone clasts occur in a pyroclastic breccia at the base of the Elise Formation. The Beaver Falls section is capped by 100 metres of maroon siltstone and pebble sandstone. Although mafic sills are absent from the upper part of the Beaver Falls section, they do occur in the Copper Creek section.

The Copper Creek section (Figure 1-2-3) is characterized by 870 metres of thin-bedded turbidite sandstone and intercalated thick-bedded siltstone and argillite. The sequence is lithologically similar to the upper part of the Mount Kelly section but is generally more thinly bedded.

Facies changes in the Archibald Formation are summarized in the stratigraphic columns of Figure 1-2-4. A wedge of very fine grained clastic rocks characterizes the base of the formation in the Mount Kelly block. This wedge pinches out to the west, supplanted and overlain by graded, coarse and fine clastic beds. Laterally discontinuous coarse clastics occur near the top of the formation in the Beaver Falls and Park Siding blocks.

The contact between the Archibald and Elise is gradational. It is mapped (Höy and Andrew, 1989a; Figure 1-2-2) where fine-grained interbedded siltstones and argillites with occasional thin flows give way to massive augite porphyry flows with fine argillaceous partings. In the Beaver Creek area, the upper(?) Archibald Formation contains a few mafic flows or sills but farther east and northeast in the Mount Kelly–Hellroaring Creek and Erie Creek areas, flows are more abundant.

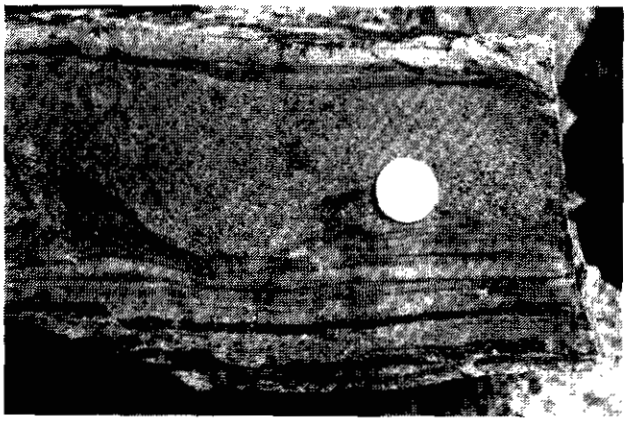


Plate 1-2-1. Thick-bedded, graded turbidite wacke with sharp basal contacts and basal scours, Archibald Formation, southwest of Salmo.

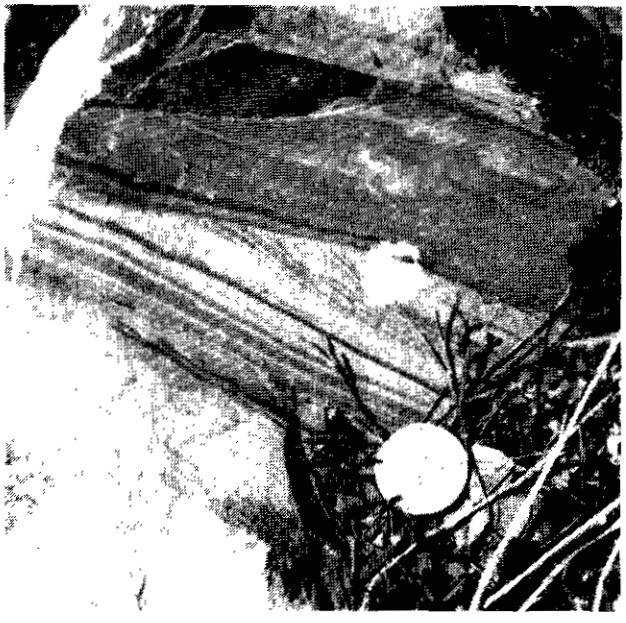


Plate 1-2-2. Crossbedding in thick-bedded, graded turbidite wacke, siltstone and silty argillite, Archibald Formation, east of Mount Kelly.

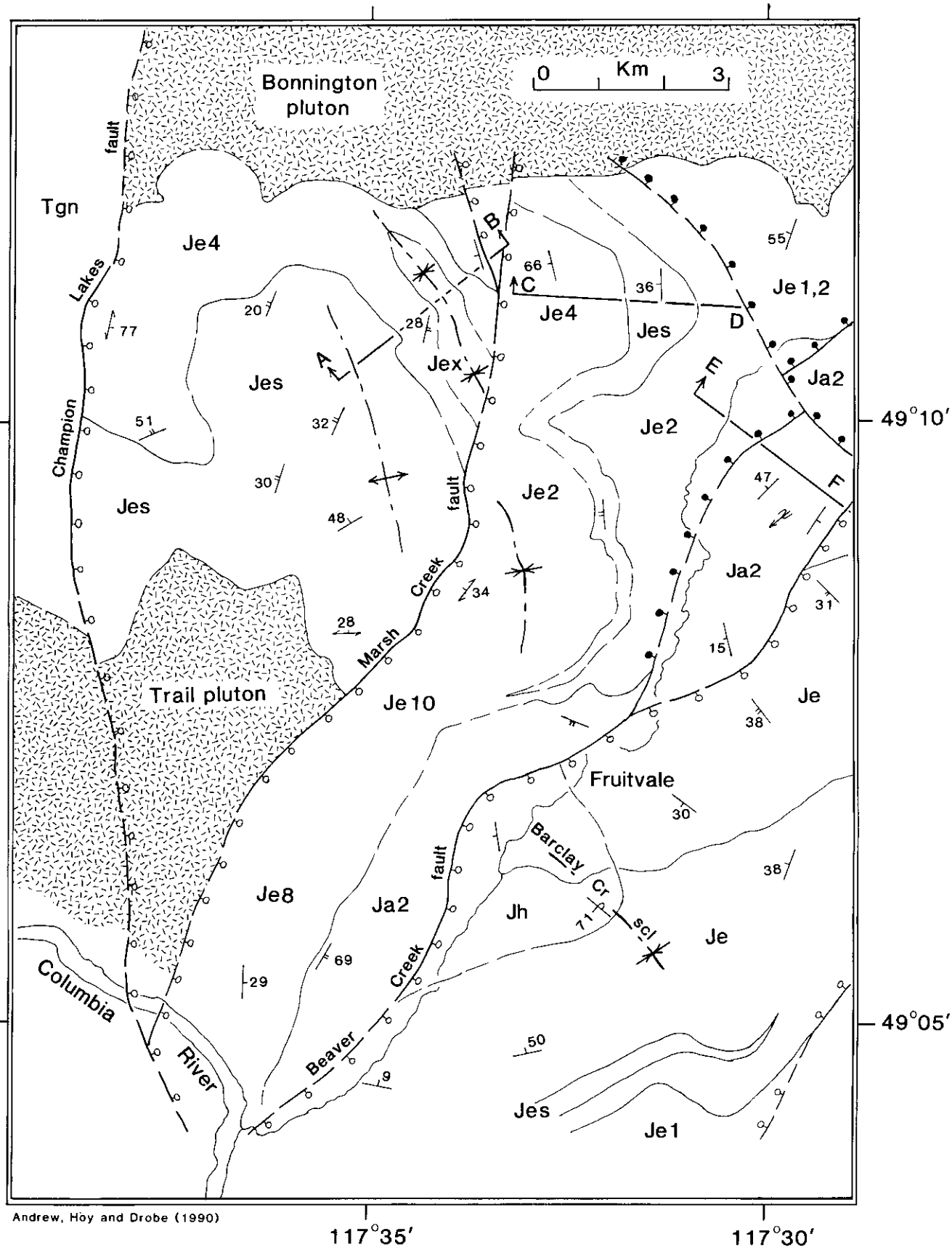
Plate 1-2-3. Matrix-supported conglomerate with limestone and siltstone clasts (0.5-10 centimetres in diameter), Archibald Formation, Beaver Creek area.

FACIES TRENDS AND INTERPRETATION

Systematic facies changes in the Archibald Formation, from dominantly conglomerates in the westernmost sections, through intermixed conglomerates and sandy turbidites in the Mount Kelly area, to fine-grained clastics in correlative Ymir Group rocks south of Nelson, indicate deposition in a large submarine fan with a western source area. The coarse clastic facies, restricted to the Beaver Falls–Fruitvale area, are laterally discontinuous subaqueous debris flows or slumps deposited on higher angle slopes than the classical turbidity current deposits. Thick sequences of A-E turbidites in the Mount Kelly–Hellroaring Creek and Erie Creek areas were deposited in a middle to lower fan environment.

The coarse conglomerates, rapid facies changes and locally subaerial siltstone and pebble sandstone in the Beaver Falls-Fruitvale area suggest deposition near a faulted basin margin. Absence of the Archibald Formation west of the Columbia River, with Elise Formation resting unconformably on Paleozoic Mount Roberts Formation (Little 1982; Fyles, 1984) indicates a tectonic high. Erosion of an uplifted fault block west of Montrose, exposing older Mount Roberts Formation, provides a source for clasts of Mount Roberts limestone in fanglomerates of the Archibald Formation.

In summary, a model for the deposition of the western facies of Archibald Formation by growth faulting is proposed. The argillite succession in the lower Archibald was deposited as muds in a marine basin that stretched from Archibald Creek to Ymir and perhaps northward to include part of the Slocan Group. The initiation of growth faulting near the southwestern basin margin produced coarse clastic facies in the Montrose–Fruitvale area and proximal turbidites in the Mount Kelly–Hellroaring Creek and Erie Creek areas. These Early Jurassic growth faults are located between the basin margin near Montrose and the uplifted tectonic high near Rossland. Final subaerial deposition in the Montrose–Beaver Falls area produced a more oxidized facies immediately prior to deposition of Elise Formation pyroclastic breccia.


Bonnington pluton
0 Km 3
fault
Tgn
Je4
Lakes
77
20
28
A
Jex
Jes
Champion
51
32
30
Jes
48
fault
Je2
B
66
C
36
Je4
Jes
55
Je1,2
D
E
Ja2
47
F
Je2
Creek
34
Marsh
28
Trail pluton
Je10
Ja2
31
15
Je
38
Fruitvale
30
Barclay Cr
fault
38
Je8
Ja2
Jh
71
scl
Je
Columbia River
69
29
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9
Jes
Je1
49°10′
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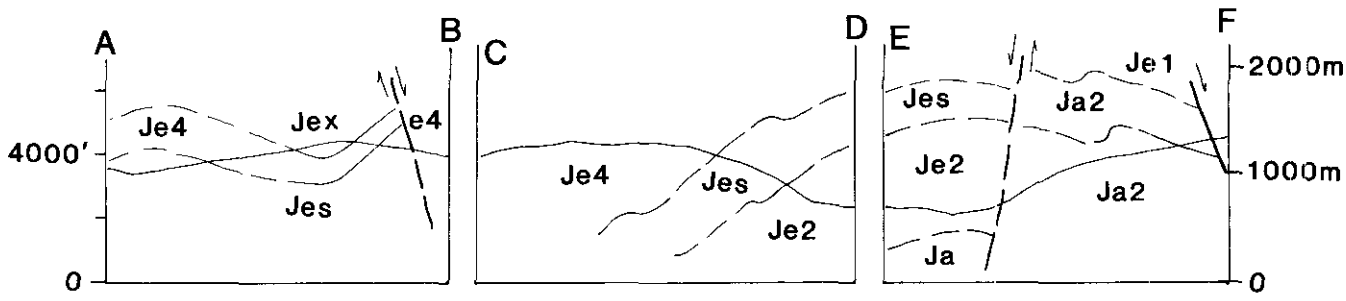
Andrew, Hoy and Drobe (1990)



Andrew, Hoy and Drobe (1990)

LEGEND

JURASSIC-CRETACEOUS

granite, granodiorite

LOWER JURASSIC

ROSSLAND GROUP

Jh — HALL FORMATION: argillite, siltstone

Je — ELISE FORMATION

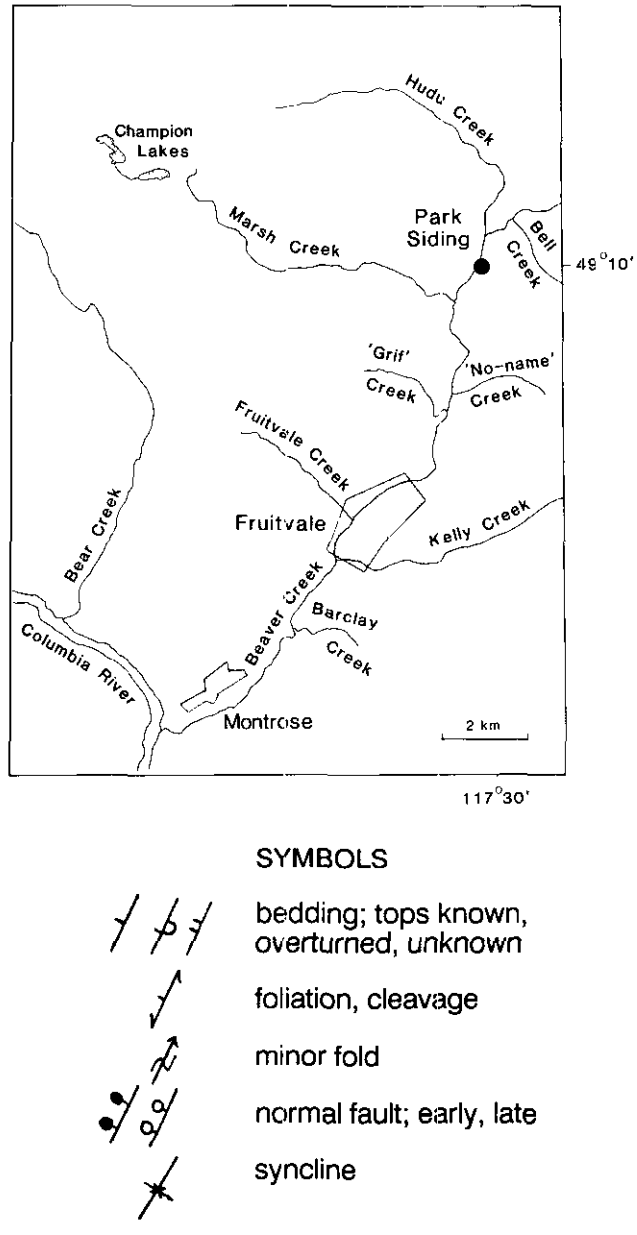
- Je10 — siltstone, argillite
- Je8 — intermediate to mafic tuff
- Jes — siltstone
- Je2 — mafic pyroclastic breccia
- Je1,4 — mafic flows, tuff

Ja — ARCHIBALD FORMATION

- Ja2 — siltstone, conglomerate

PALEOZOIC

Tgn — TRAIL GNEISS



SYMBOLS

- bedding; tops known, overturned, unknown
- foliation, cleavage
- minor fold
- normal fault; early, late
- syncline

Figure 1-2-2. Geological map of the Beaver Creek area, Rossland-Trail east-half map sheet (after Andrew *et al.*, 1990; Fitzpatrick, 1985; Little, 1962, 1982).

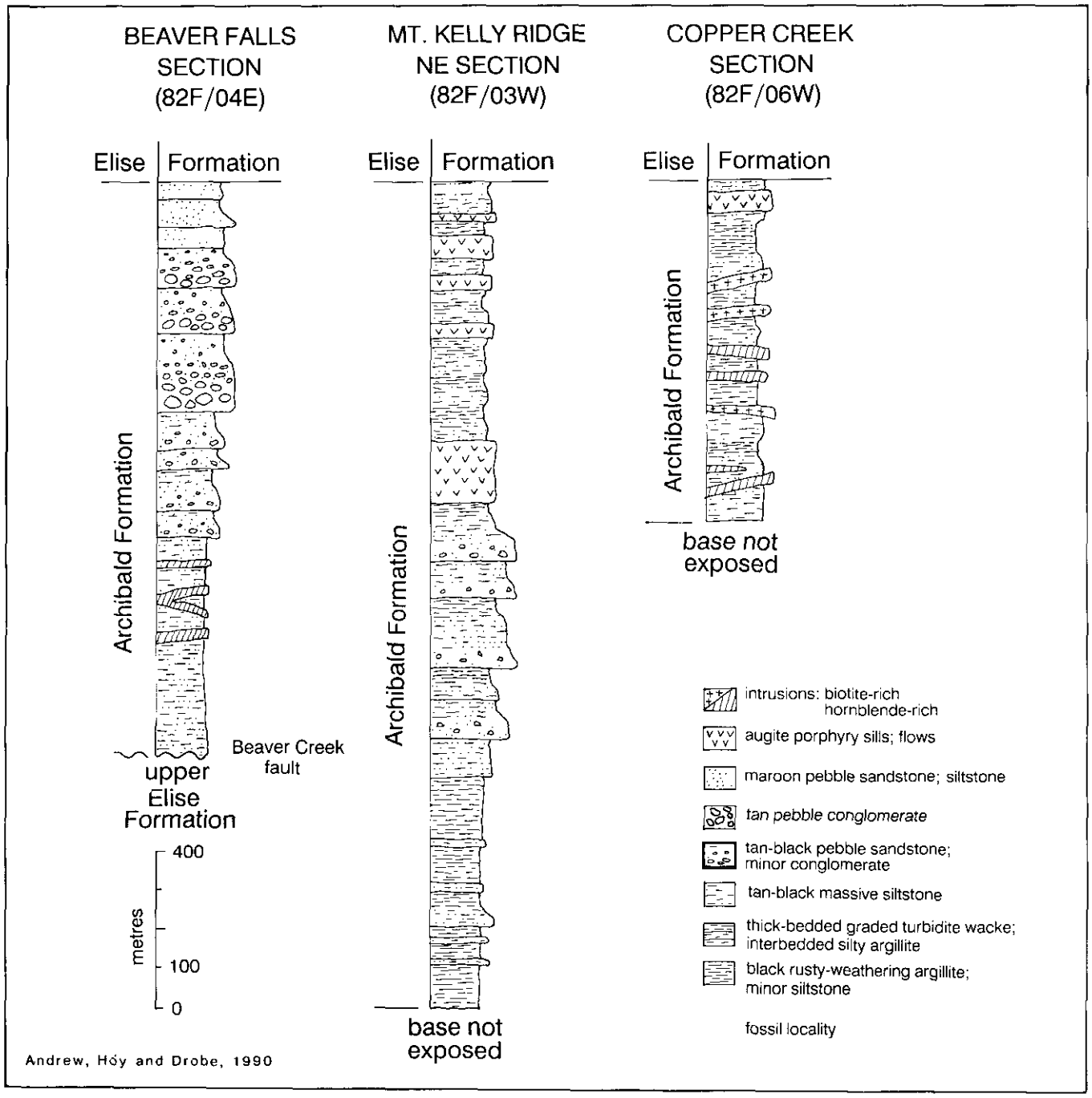


Figure 1-2-3. Stratigraphic sections of the Archibald Formation, Beaver Creek, Mount Kelly and Erie Creek areas.

ELISE FORMATION

The Elise Formation, named for exposures on the western slopes of Mount Elise south of Nelson, is characterised by massive and brecciated flows, subvolcanic porphyries, pyroclastic, tuffite and minor epiclastic deposits. The broad subdivision of the Elise Formation into a lower succession of mafic flows and an upper succession of intermediate to mafic pyroclastic rocks, recognized locally in the Nelson area (Andrew and Höy, 1988), is also applicable in the Beaver Creek, Salmo and Tillicum Mountain areas (Höy and Andrew, 1990a, b; W. Roberts, personal communication, 1988).

Although the Elise Formation conformably overlies the Archibald Formation in the Beaver Creek area, fossil evidence and, as previously mentioned, lithologic correlation indicate that the contact shows temporal transgression on a regional scale. Sinemurian fossils, diagnostic of the Archibald Formation, are also found in siltstone intervals in the basal part of the Elise Formation (Little, 1962, 1982).

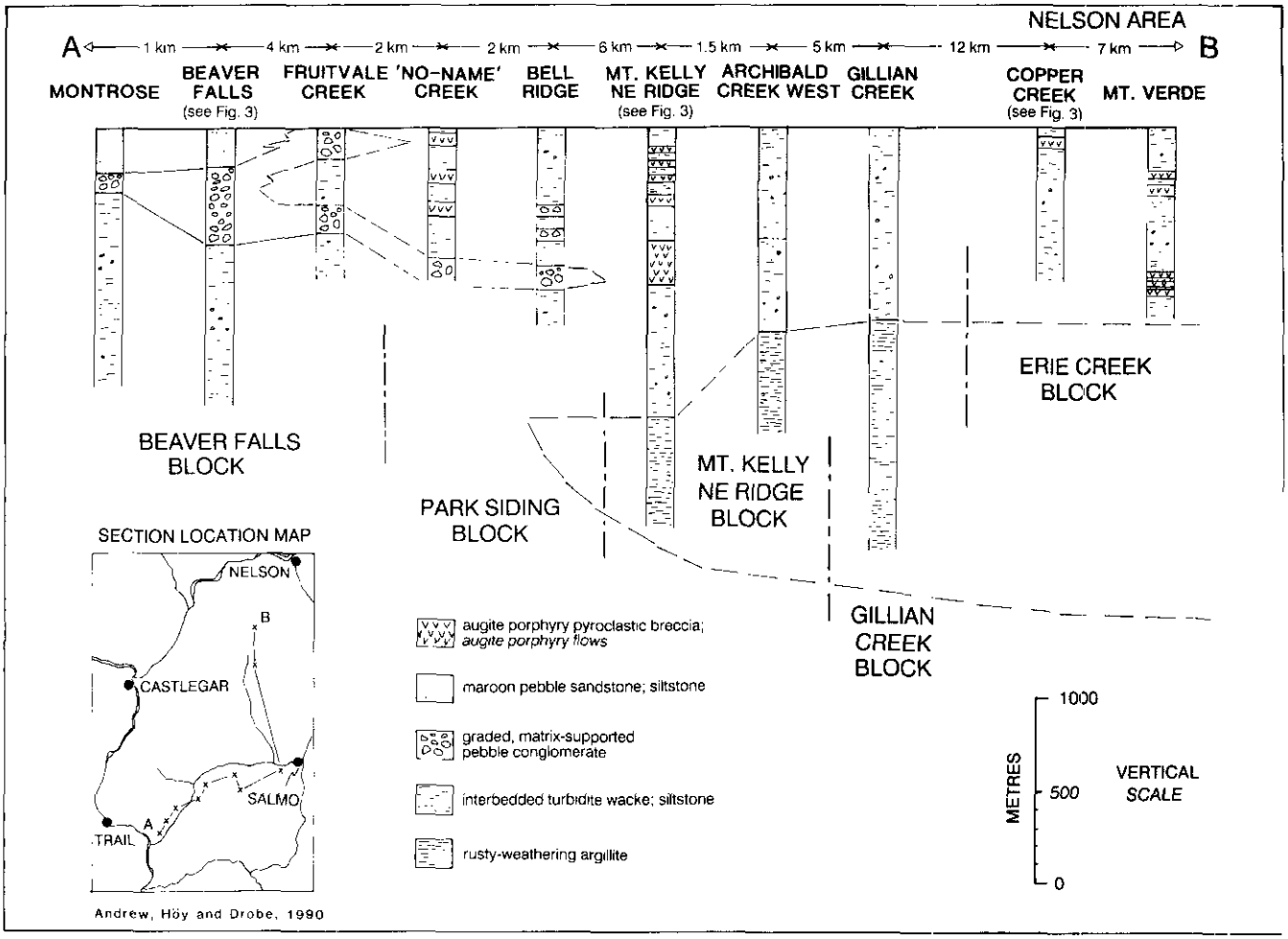
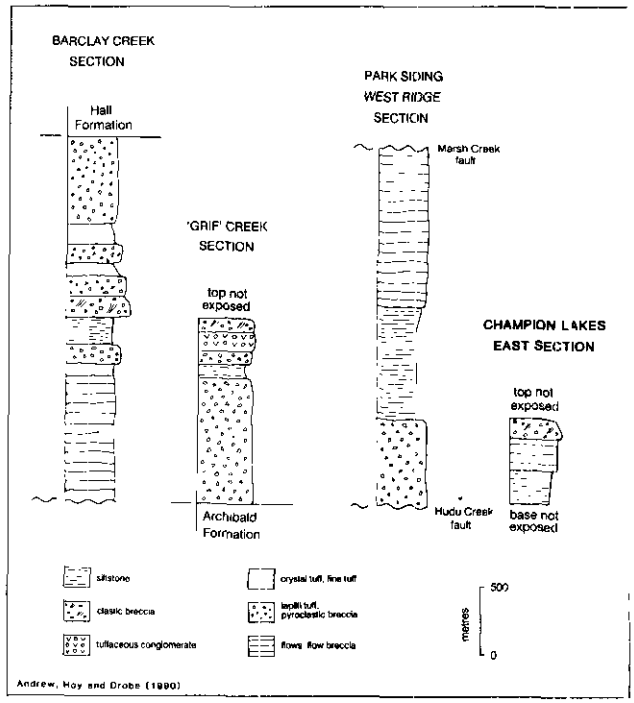


Figure 1-2-4. Correlation chart of the Archibald Formation showing main lithologic and thickness changes.

The basal part of the Elise Formation conformably overlies the Archibald Formation in the Beaver Creek area. Lateral facies changes are rapid; it comprises mafic pyroclastic breccia north of Fruitvale whereas intermediate pyroclastic breccia predominates west of Montrose (Figure 1-2-2). Elsewhere the base of the Elise is not exposed or is cut by faults. The top of the formation is exposed in a broad syncline southeast of Fruitvale. It comprises interlayered mafic and intermediate lapilli tuff, ash tuff and a prominent section of interbedded siltstone and argillite that is conformably overlain by the Hall Formation.

Facies changes in the Elise Formation in the Beaver Creek area complicate division into lower and upper members. Near Barclay Creek, southeast of Fruitvale, the formation may be separated into a lower section of augite porphyry flows and flow breccia approximately 950 metres thick, overlain by 1800 metres of lapilli, crystal and fine tuff (Figure 1-2-5). Autoclastic fragments in flow breccia outcrops at the headwaters of Nine Mile Creek and north of *Doubtful Creek contain calcite-filled amygdules.*

Near 'Grif' Creek north of Fruitvale, however, the distinction between upper and lower Elise is less evident. The total thickness of the formation here is approximately 1400 metres. It comprises dominantly mafic pyroclastic breccia overlain by tuffaceous conglomerate and clastic breccia



containing several per cent angular siltstone and volcanic clasts. In contrast, the Elise Formation in the Park Siding section to the northeast is characterised by at least 2750 metres of mafic pyroclastic and effusive rocks interbedded with a thick succession of siltstone (Figure 1-2-2). In the Champion Lakes area, exposures of the Elise Formation are flat-lying to gently folded and comprise flows, flow breccias and clastic breccias that overlie a succession of thinly bedded and finely laminated siltstone of unknown thickness (Figures 1-1-2 and 5). It is possible that this siltstone succession, included as part of the Elise Formation (Little, 1982; Figure 1-1-2), may be the upper part of the Archibald Formation.

Growth faulting, initiated during deposition of the Archibald Formation, probably continued in the early Elise. The occurrence of Mount Roberts limestone clasts and granitic clasts in pyroclastic breccia at the base of the Elise Formation indicates proximity to an uplifted fault block or tectonic high to the west. Volcanic facies in the lower Elise indicate explosive volcanism began in the 'Grif' Creek and Park Siding west ridge areas while effusive eruptions occurred in the Champion Lakes, Barclay Creek and 'No-name' Creek areas.

Hall Formation

Approximately 300 metres of the Hall Formation is exposed in the core of the Barclay Creek syncline south of Fruitvale. It rests conformably on upper Elise mafic pyroclastic breccia, lapilli tuff and fine tuff and is characterised by dominantly black carbonaceous argillite and tan siltstone, similar to the basal part of the formation in the Nelson and Salmo areas. Coarse clastic facies that typify much of the upper Hall Formation are not exposed here. The formation is dated by Toarcian pelecypods found on Bath Creek road southwest of Fruitvale (Little, 1982).

STRUCTURE

The Beaver Creek area lies north of the Waneta fault, a thrust that juxtaposes Rossland Group rocks in Quesnellia against North American miogeoclinal rocks, and east of the southern extension of the late Eocene Champion Lakes–Slocan normal fault. Two periods of pre-Middle to Late Jurassic compressional tectonics are recognised to the southeast (Höy and Andrew, 1990a). Near the Waneta fault, northeast-trending tight folds, associated shearing and a penetrative foliation are related to shearing along the fault. A series of northeast-trending folds in the Archibald Formation, in a fault-bounded structural block northeast of Fruitvale, may also be a result of this early deformation (Figure 1-2-2).

More open, south to southeast-trending folds with an axial planar cleavage and, locally, associated crenulation cleavage are superposed on the earlier folds (Plate 1-2-4). They are cut by two generations of normal faults and by the Late Jurassic plutons.

A northeast-trending, west-dipping normal fault follows the Beaver Creek valley north of Fruitvale. It juxtaposes Elise Formation in its hangingwall against folded Archibald Formation to the southeast. It is cut by a northwest-trending fault that parallels Hudu and Bell Creeks (Figure 1-2-2; Höy and Andrew, 1990a, this volume, Figure 1-2-2), which is also assumed to be an early (pre-intrusion) normal fault.

Plate 1-2-4. Crenulation cleavage superposed on early folds in interbedded siltstone and argillite, Elise Formation, Champion Lakes area.

The latest structures are post-intrusive, northeast-trending normal faults and north-trending dikes. The Champion Lake fault (Little, 1962; Simony, 1979) is the southern extension of the Slocan fault (Parrish, 1984; Parrish *et al.*, 1988) along which east-side-down normal displacement decreases systematically southward, from approximately 10 kilometres at Slocan Lake (Carr *et al.*, 1987) to 1 to 2 kilometres near the Trail pluton (Corbett and Simony, 1984) to its termination in the Columbia River valley north of the Waneta fault. Some of this displacement may be transferred to a complex, but dominantly northeast-trending array of normal faults in the Beaver Creek area (Figure 1-2-2) and to the east in the Mount Kelly area (Höy and Andrew, 1990a, b). The Marsh Creek fault is a splay of the Champion Lake fault that forms the eastern boundary of the Trail pluton and cuts second generation, northwest-trending folds farther north (Figure 1-2-2). The Beaver Creek fault to the southeast has several kilometres of displacement along it, locally placing Hall Formation against Archibald Formation. North-trending diorite and rhyolite dikes of Eocene age(?) form a swarm extending from Montrose to just east of Champion Lakes (Andrew *et al.*, 1990).

In summary, structures in the Rossland–Trail east-half area record at least four tectonic events. Tight folds, shears and a penetrative foliation are associated with the Waneta thrust; open south-plunging folds superposed on these earlier folds record continued compressive strain. They are cut by west-side-down normal faults, possible extensions of the Red Mountain fault in the Nelson area (Höy and Andrew, 1989a). These structures predate the Late Jurassic Bonnington, Trail and Nelson plutonic rocks. East-dipping normal faults, including the Champion Lake fault, and north-trending dikes record an Eocene extensional event that is related to development of core complexes along the eastern margin of the Shuswap complex.

MINERAL OCCURRENCES

Despite potential for shear-related conformable gold, gold-copper skarn, and precious metal vein deposits, little

systematic exploration has been documented in the Beaver Creek area prior to 1988. The Canada Day Red showing, a north-trending zone of rusty, pyritic, chlorite-epidote-muscovite-altered tuffaceous conglomerate and clastic breccia over a kilometre long, occurs at the headwaters of 'Grif' Creek. Geophysical, geochemical and geological surveys of this zone were undertaken by Noranda Exploration Company, Limited in 1988 and 1989. Elise Formation siltstone is locally hornfelsed and pyritized around Tertiary diorite dikes east of Montrose and southeast of Champion Lakes. Several small abandoned workings were found during the course of regional mapping (Andrew *et al.*, 1990); typically these are mineralized shear zones and quartz veins a few centimetres to a metre wide that contain variable sulphide content.

ACKNOWLEDGMENTS

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NOTES