# THE BLUE DOME FAULT: THE EVOLUTION OF A TRANSFORM STRUCTURE INTO A THRUST FAULT IN THE SYLVESTER ALLOCHTHON, CASSIAR MOUNTAINS, BRITISH COLUMBIA*
# (104O/9, 16; 104P/12, 13)

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*KEYWORDS:* Structural geology, ophiolites, Blue Dome fault, Sylvester allochthon, transform faults.

## INTRODUCTION

The Blue Dome fault plays a major role in the architecture of the Sylvester allochthon. It runs nearly the entire length of the allochthon (Figure 1-21-1), a northwest-trending zone of anastomosing faults, in general dipping more than 45° to the southwest. Prior to the 1989 field season it was known to extend as far south as the Dease River, and as far north as Blue Dome. Limited field observations suggest it does not pierce the basal thrust of the allochthon either to the south (H. Gabrielse, personal communication 1988) or to the north in the Tootsee Lake map area. This field relationship, which would establish it as a pre-emplacement fault, was investigated by detailed field mapping in the area northwest of Blue Dome in 1989.

## NATURE OF THE BLUE DOME FAULT ZONE

The Blue Dome fault zone is generally steeply dipping, in contrast to the myriad Sylvester thrust faults, which are flat to gently dipping. In several localities it truncates such thrusts, for instance the Division II/Division I contact on Mount Pendleton and Blue Dome (Figure 1-21-1). It and its splays contain pods of scaley serpentinite which tend to be serpentinite mélanges containing blocks of gabbro and polymictic depositional breccia with clasts of ultramafic and lower crustal rocks (Plate 1-21-1a). Displacement indicators from the serpentinites (Nelson and Bradford, 1989; and field observations with V. Hansen, 1989) show predominantly dextral transcurrent motion.

The Blue Dome fault marks a Mississippian volcanic facies boundary (Nelson and Bradford, 1989). East of it, Division I, the lowest sedimentary division of the Sylvester allochthon, is very thick because of the presence of Unit IMsi, a sequence of Mississippian black argillite, chert, sandstone and calcarenite. This unit is structurally overlain by Pennsylvanian-Permian basalts (Unit IIPPvs) at the base of Division II. West of the Blue Dome fault, Division I is very thin; the basal unit of Division II, Unit IIMvs, is a sequence of Mississippian sediments identical to those in Unit IMsi, but interbedded with 10 to 90 per cent basalts.

Unpublished aeromagnetic data at 1:25 000 scale from the Sylvester allochthon, kindly provided by Brinco Ltd. (now Western Canadian Mining Corporation), reinforce the concept of a steep dip and the anastomosing nature of the Blue Dome fault zone. In contrast with gently dipping ultramafic sheets such as the Zus Mountain and Blue River bodies, the magnetic signature of the Blue Dome fault is a string of linear highs flanked to the east by magnetic lows. This string may bifurcate, as west of Hot Lake, where two linear magnetic highs coincide with the two sides of Unit IIMPvsu, a slivered supracrustal unit which Nelson and Bradford (1989) included within the Blue Dome fault zone. Similar splays are indicated in the area of limited exposure southeast of the Blue River in the Blue Dome map area. One of these splays, located 5 kilometres east of the Blue River, contains serpentinite and gabbro breccia. It is overlain by a small outlier of Triassic Table Mountain limestone, from which Norian conodonts have been recovered (M.J. Orchard, personal communication, 1987). This relationship suggests that motion on the Blue Dome fault was pre-Late Triassic.

## NATURE OF THE BLUE DOME FAULT ZONE IN 1989 MAP AREA

Field mapping in 1989 covered the northwestern edge of the Blue Dome map area (104P/12), the northeastern corner of the Chromite Mountain map area (104O/09), the southeastern corner of the Tootsee Lake map area (104O/16) and the southwestern corner of the One Ace Mountain map area (104P/13). Like most map-boundary regions, this contained much essential information. The Blue Dome fault zone at this location is roughly 1 kilometre wide. It consists of scaly, tectonized serpentinite that encloses blocks and slivers of coarse-grained gabbro and polymictic breccias. The polymictic breccias are similar to those described elsewhere along the Blue Dome fault (Nelson *et al.*, 1988a, Nelson and Bradford, 1989). Clasts include coarse-grained gabbro, serpentinite, basalt, diabase, greenschist and chert. At several exposures breccias consisting of sand-sized clasts are interbedded with grey argillaceous cherts that contain sponge spicules. Conodont determinations on the cherts are in progress.

On the ridge 15 kilometres northwest of Blue Dome, the Blue Dome fault zone dips steeply west but flattens abruptly eastward, in continuous outcrop, to form a tongue-like structure as shown in cross-section A-A′ Figure 1-21-2. It forms several flat klippen on the crest of the ridge. These klippen appear on the 1:25 000 map (Nelson *et al.*, 1988b), but were not considered to be part of the Blue Dome fault zone. Continuing north, Rocky Top, the southernmost ridge in the Tootsee Lake map area, mapped in 1986 as microdiorite (Nelson and Bradford, 1987), and later assigned to Division III, is underlain by gabbro breccias and diabases of the Blue Dome fault zone. This ridge exposure extends 5 kilometres in a southwesterly direction, perpendicular to the strike of the Blue Dome fault zone. Given the structura

* This project is a contribution to the Canada/British Columbia Mineral Development Agreement.

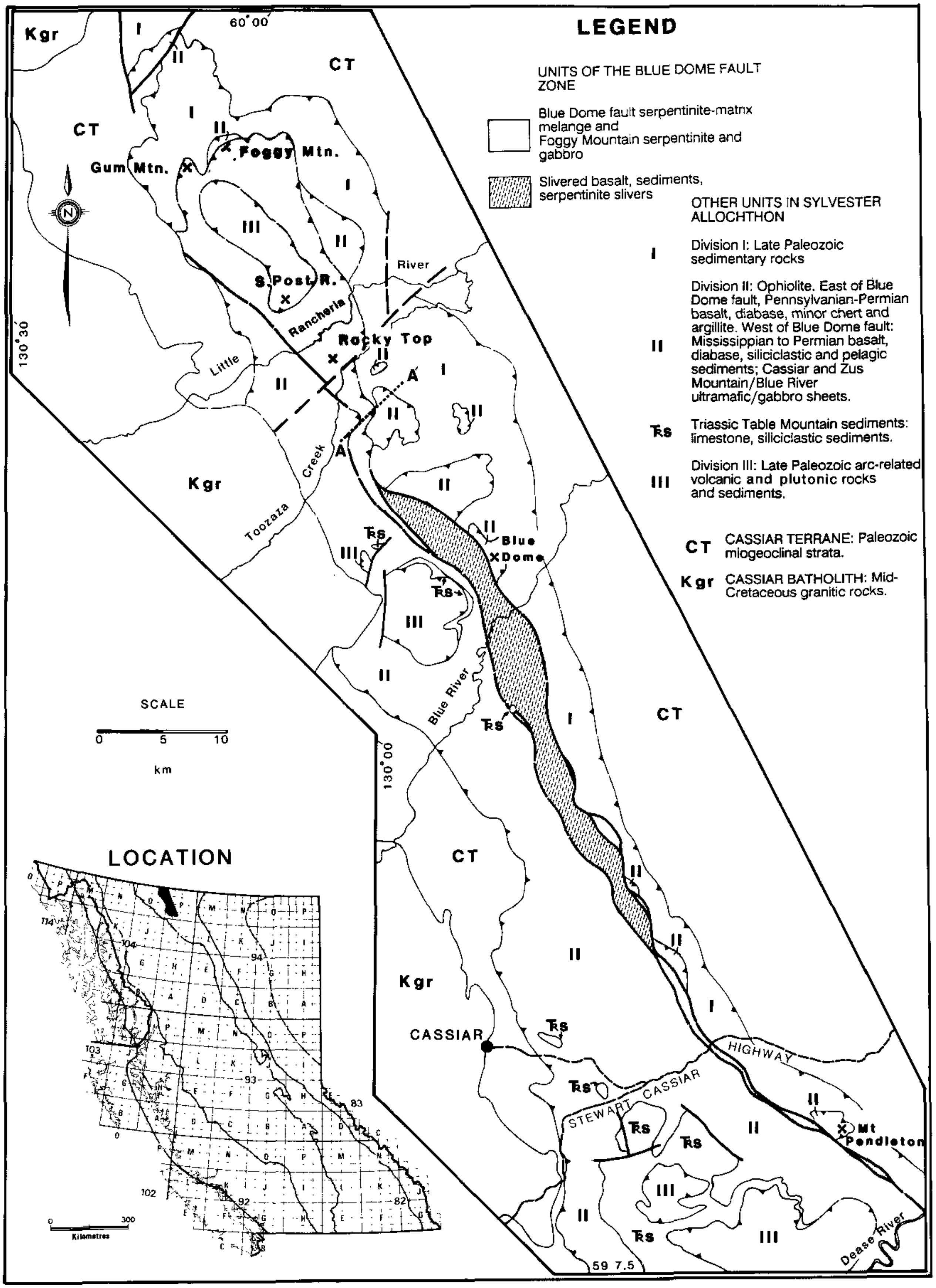


Figure 1-21-1. Regional map of the Blue Dome fault zone (south of Rocky Top) and the Foggy Mountain serpentinite mélange (Rocky Top and north). These two units are continguous and correlative, differing only in that the Blue Dome fault zone is a crosscutting feature while the Foggy Mountain body is a gently dipping, sheet-like unit bounded by thrusts.

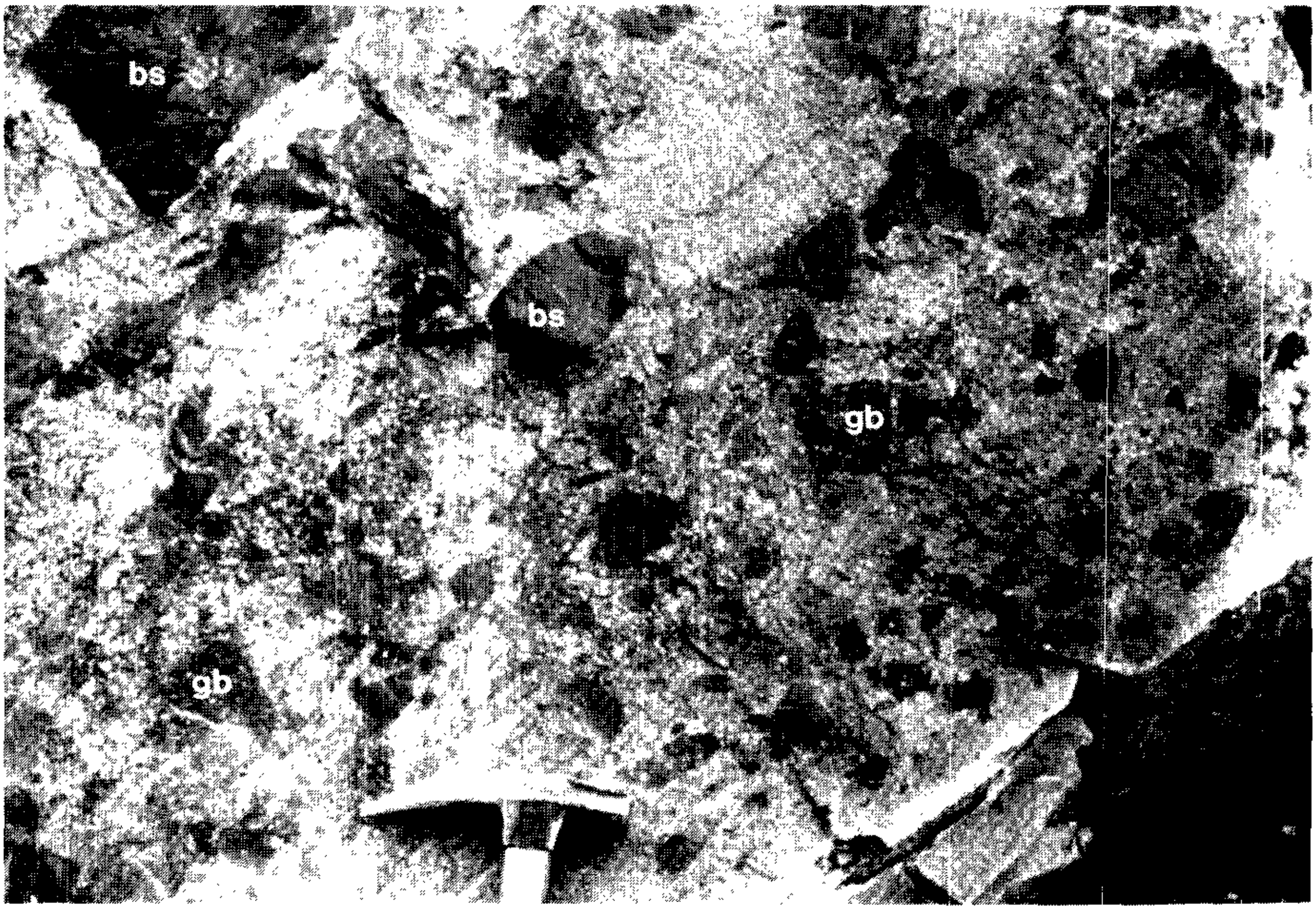


Plate 1-21-1a. Typical polymictic depositional breccia from a sliver within the Blue Dome fault zone, containing elements of oceanic lower crust and upper mantle (bs = basalt, gb = gabbro).

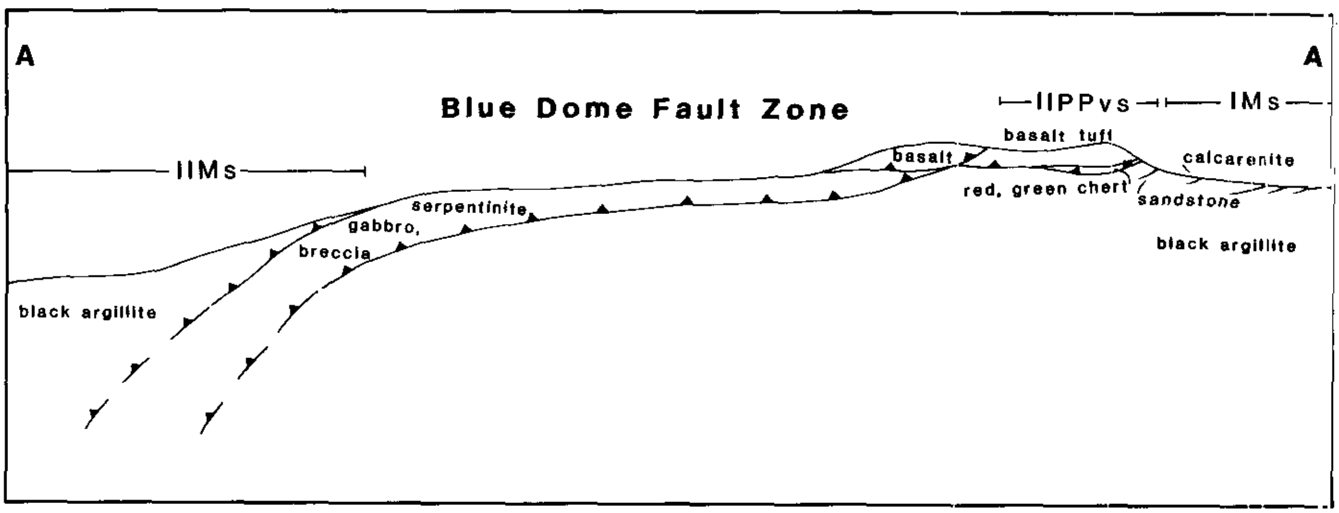


Figure 1-21-2. Cross-section of northern Blue Dome fault zone, in the area where it flattens in an easterly direction to merge into the Foggy Mountain body. IMs – Mississippian siliclastic sediments; IIMs = Mississippian siliciclastic sediments, interbedded with basalts to west; IIPPvs = Pennsylvanian – Permian basalt, diabase, chert, argillite.

flattening of the fault zone immediately south of it, it is reasonable to show the Blue Dome fault on Rocky Top is an essentially flat thrust sheet. This sheet would then project northward into the serpentinites of western South Post Ridge, which correspond to the Foggy Mountain gabbro and ultramafite (*see* Nelson and Bradford, 1987).

The Foggy Mountain body is a typical dismembered ophiolite within the Sylvester allochthon. It is a flat sheet that rests either directly on cherts and argillites of Division I or is separated from them by thin slivers of basalt. It is structurally overlain by the Division III trachyandesite-pyroclastic package on South Post Ridge. The Foggy Mountain body is a tectonized serpentinite that contains mountain-sized blocks of coarse-grained gabbro, amphibolite (mylonitic gabbro), a basaltic dike complex, and a variety of breccias: gabbro breccia, epidote-rich brecciated actinolite-quartz mylonite, and a block on Gum Mountain of depositional polymictic breccia in a limestone host (Plate 1-21-1b) which has yielded Permian conodonts (M.J. Orchard, personal communication, 1988). The correlation of the Foggy Mountain unit with the Blue Dome fault zone is an important step in unravelling the deformational history of the Sylvester allochthon.

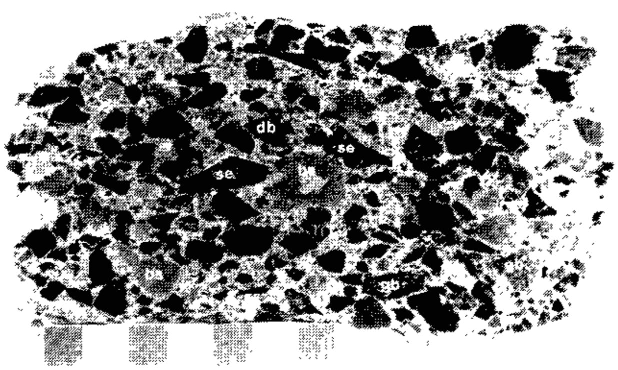

Plate 1-21-1b. The Gum Mountain breccia sliver. The limestone matrix has yielded Permian conodonts. Clasts include basalt, coarse-grained gabbro identical to gabbro that outcrops of Foggy Mountain, diabase and red and green chert.

## DISCUSSION AND CONCLUSIONS

Substantial evidence can now be brought together to constrain the timing and nature of motion on the Blue Dome fault zone and its evolving role as a major crustal break within the Sylvester allochthon. Its earliest motion is recorded by the polymictic depositional breccias. The Permian age of the Gum Mountain breccia is now seen as the age of a breccia sliver that formed within the fault zone. This age is equivalent to basalts and sediments in the crustal packages that surround it. It is likely that the Blue Dome fault was initially a transform structure within the marginal basin in which the basalts and sediments of Divisions I and II were accumulating. Diapiric emplacement of serpentinite mélange into high levels in the fault zone occurred at this time. These diapirs, termed "protrusions" by Saleeby (1984) probably reached the sea floor. The breccias formed at the bases of fault scarps and serpentinite protrusions. The spiculitic cherts interbedded with the polymictic breccias, observed in 1989, are a further link between the breccias and typical Late Paleozoic Sylvester sedimentation.

The low-angle dextral displacement indicators in serpentinites – slickenfibres, slickensides and S-C structures, may represent this early motion or, given the ductile nature of serpentinite, any later phase. The fact that the Blue Dome fault truncates thrust faults indicates that at least part of its motion succeeded initial shortening within the allochthon; transcurrent strain may have been partitioned into it during a transpressional event (V. Hansen, personal communication, 1989). Concurrently, or later, the steep Blue Dome fault zone itself was carried and flattened to the east by easterly vergent thrusting. It now consists of two parts, a steep root and a flat thrust composed of serpentinite mélange. In general, it carries Mississippian to Permian volcanics and sediments of Division II (Units IIMvs and IIPPvs) in its hangingwall. On South Post Ridge in the Tootsee Lake map area, however, these hangingwall units are missing and it is directly overlain by Division III. The abrupt disappearance of Division II above it can be accounted for by assuming one thrusting event that brought Division II over the Blue Dome fault zone/ Foggy Mountain body; an interval of erosion; then thrust emplacement of Division III over everything. The time of the interval between these two separate shortening events has been inferred to be Late Triassic, as shown by relationships on Table Mountain in the Cassiar area (Nelson and Bradford, 1988). The onlapping Triassic limestone on the Blue River fault zone southeast of the Blue River provides further evidence for pre-Late Triassic motion. The major motion on the Blue Dome/Foggy Mountain thrust was, then, a Sonoman-aged event.

The root zone of the Blue Dome fault is truncated by the base of the Sylvester allochthon. This "out-of-sequence" relationship – that is, truncation of a thrust by a second thrust located further toward the hinterland – can again be explained by two separate shortening events, one pre-Late Triassic, the second the emplacement of the allochthon after Late Triassic but before mid-Cretaceous time. These events are summarized in the sketches in Figure 1-21-3.

The inferred history of the Blue Dome fault zone, consists of four phases:

(1) Early Permian and earlier(?): oceanic transform fault within the marginal basin in which Divisions I and II of the Sylvester allochthon were formed.
(2) Late Permian to Early Triassic: transcurrent fault during Sonoman crustal shortening of the marginal basin; finally conversion to a flat easterly verging thrust, the Foggy Mountain serpentinite mélange.
(3) Late Triassic: erosional truncation of early structures; deposition of Table Mountain sediments on top of the thrust-imbricated Late Paleozoic units.
(4) Early Jurassic(?): Blue Dome fault carried east as passive structure during thrusting of Division III on Division II and of the Sylvester allochthon on the North American continental margin.

The steep root of the Blue Dome fault happens to be preserved within the Sylvester allochthon. Given that the allochthon is a very narrow klippe that contains a number of

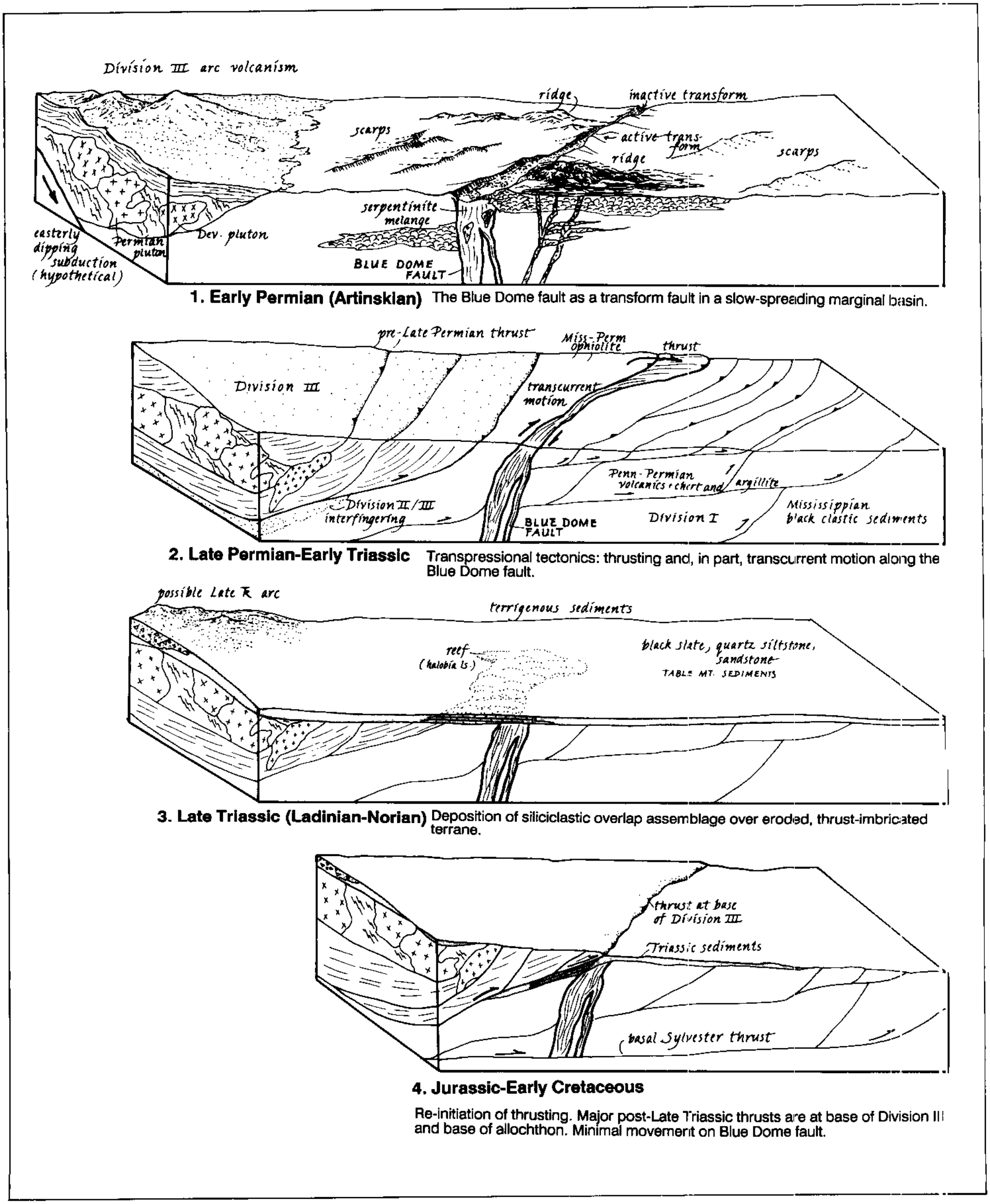


Figure 1-21-3. Inferred history of the Blue Dome fault.

sheets of ultramafite and serpentinite mélange, it is likely that these also once had steep roots which have now been removed by erosion of more westerly parts of the allochthon. The existence of the Blue Dome fault, with its complex history, suggests that all of these mantle-derived sheets – the Zus Mountain/Blue River and Cassiar sheets (Nelson and Bradford, 1989) – may once have lain along transform faults separating different crustal segments. It rationalizes their presence within the allochthon, interleaved with sequences of upper crustal rocks. It explains why the allochthon does not contain complete lower crustal-mantle ophiolite sequences, but rather chips, blocks, pods and fragments such as are found along modern transform faults. Finally, as suggested by Karson and Dewey (1978) and Saleeby (1984), the Blue Dome fault provides a clear example of the evolution of a pre-accretion crustal discontinuity into a major thrust.

## ACKNOWLEDGMENTS

The ideas expressed in this paper developed substantially during discussions with Vicki Hansen, who predicted the flattening of the Blue Dome fault.

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