Ripogenus Formation, Northern Maine - age, sequence stratigraphy, and significance of syn-depositional tectonism

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Abstract

Detailed mapping reveals that a major sequence boundary (erosion surface) exists within the shallow marine strata of the Ripogenus Formation near the Ripogenus Dam in northern Maine. An orthoquartzite unit within the formation rapidly varies in thickness from 0-20 meters over distances of a few hundred meters. We infer that this rapid thickness change is due to the filling of paleotopography including significant paleorelief in the form of valleys. This erosion surface cuts into the distinctive "pitted" unit of the Ripogenus Formation, predominantly fine-grained calcareous quartz arenites, interbedded with lenticular limestone that is abundantly stromatoporoid-bearing. These lower strata of the Ripogenus Formation have yet to be paleontologically well- dated, at these exposures. A previously reported conodont-based age, of late Ludlow to early Lochovian, dates a bedded limestone member (a few meters thick) immediately overlying the orthoquartzite. An older regional study reported a possible mid-upper Llandovery age, from brachiopods, for the strata likely equivalent to the pitted arenite-limestone unit. Near the Ripogenus Dam the conodont-dated limestone is overlain by a thick (~50m) limestone breccia, which we interpret to be derived from mass wasting of post-orthoquartzite limestones, and initiated by syn-depositional normal faulting of the Ripogenus Formation. A section of ~100 meters of deeper-water mudrocks and interbedded pinstripe quartzite siltites (probable contourites), which overlies the limestone breccia, gives evidence of an event of coeval rapid subsidence. Mafic volcanics (West Branch) succeed the mudrocks and are also probably linked to the faulting and rapid subsidence we infer for the upper part of the Ripogenus Formation. This overall event sequence can be readily integrated with a model of flexural forebulge and outer foredeep normal faulting in connection with the start of the Acadian orogenic event in north-central Maine.

Stratigraphy

Erosion Surface and Quartzite ① ②

Previously, the Silurian-earliest Devonian sedimentary strata of the Chesuncook region have been combined in one stratigraphic unit, the Ripogenus Formation. Our recent mapping (see Map - Fig 1, and derived stratigraphic column - Fig 2) reveals that there is evidence of a significant erosion surface (sequence boundary) within this unit, marked by the overlying orthoquartzite which is a basal transgressive unit on the erosion surface. In places the quartzite varies in thickness from 0-20 meters over distances of a few hundred meters, and is also absent within continuous outcrop just west of the Ripogenus Dam (Fig 1). The quartzite is very hard and more resistant to erosion than the surrounding units, so we think that it is also thin or absent in places where it does not outcrop. We interpret the map distribution to be due to flexural uplift of the underlying pitted sandstone unit followed by initial subsidence and filling by littoral arenites of paleo-valleys eroded into the underlying calcareous pitted sandstone unit. Small cross-faults occur in association with the most prominent and well-defined quartzite-filled valley (Map- Fig 1); these could be interpreted to be syn-depositional normal faults.

Thin limestone, and stratigraphic age ③

A conodont-based stratigraphic age has been reported by Bradley et.al.(2000) from a thin (1-2 meters) limestone which is located immediately above the Quartzite and at the base of the Limestone Breccia unit (Fig 1); the age call for this limestone is late Ludlow to early Lochovian. Boucot and Heath (1969), based on brachiopod faunas from strata equivalent to the older Pitted Sandstone, suggested that some of this unit was as old as later Llandovery (C3-C5), although they also found Wenlock and Ludlow ages. We are in the process of trying to confirm this older age of the Pitted unit using conodonts. No other fossil ages have been determined for the strata in this map area; as also reported by Bradley et al (2000), the strata must all be older than the cross-cutting Katadhin Granite (U/Pb zircon age of ~407+/-1Ma).

Limestone Breccia ④

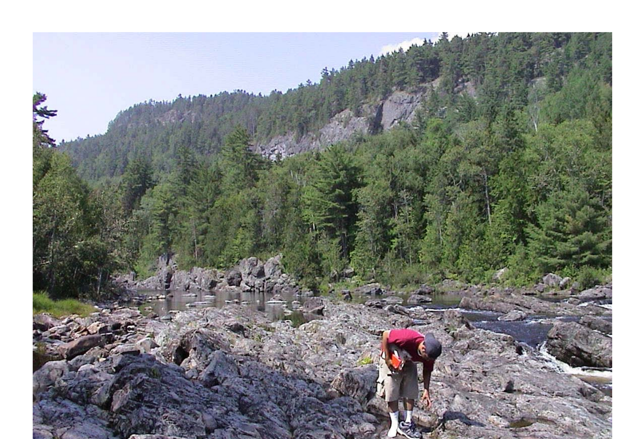
Directly overlying the pitted sandstone unit, or quartzite, where present, is a substantial and continuous unit of limestone breccia (up to about 50 meters thick). The best exposures show that the thin bedded limestone at the base grades up into and provides fragments to the basal breccias. A rusty-weathering fine-grained arenaceous matrix (both quartz and carbonate) occurs between typically very angular limestone clasts in the breccia, and in fractures which penetrate the bedded limestone below. The clasts within this unit range from occasional 2 meter boulders near the base to pebble size near the top, but are typically cobble-sized. The matrix is a more shaly or mudrock material in some places, and particularly in the uppermost, pebbly breccias. We infer that the origin of the breccia, and the overall large-scale graded distribution, is due to talus deposition adjacent to a substantial, probably normal, fault scarp. The thickness of the breccia, and the fact that it is overlain by silts and mudrocks showing no shallow-water features, implies that more rapid subsidence began in association with this event.

Ⓐ Outcrop of orthoquartzite in the thickest development - part of the valley-fill inferred from the map.

Ⓑ Base of the limestone breccia with matrix invading cracks in the underlying limestone.

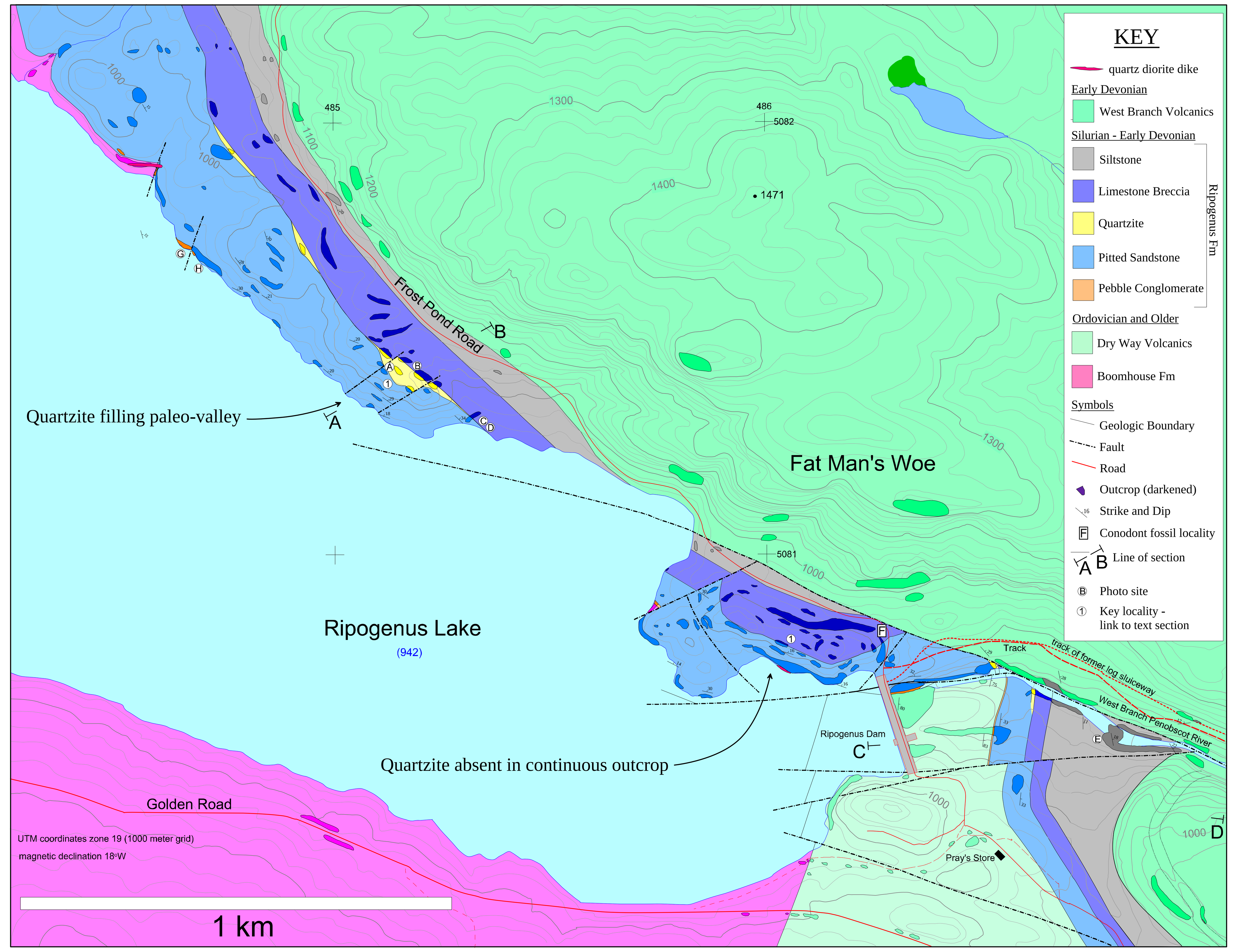
Ⓒ Typical limestone breccia.

Ⓓ Limestone breccia with large limestone boulder.



Ⓔ Bedded mudrocks and siltstones in the gorge of the West Branch Penobscot River below the Ripogenus Dam. Basalt volcanics of the West Branch Fm. extend from the far bank of the river to the hill called Fat Man's Woe on the skyline.

Fig 1. Geological Map of the Ripogenus Dam area, Maine



Ⓖ Red and pale arenites of the basal Ripogenus Formation overlain by the lowest pitted calcareous sandstones.

Ⓗ Pitted calcareous sandstones of the Ripogenus Formation on the shore of Ripogenus Lake.

Fig 2. Stratigraphic Column of the Ripogenus Formation

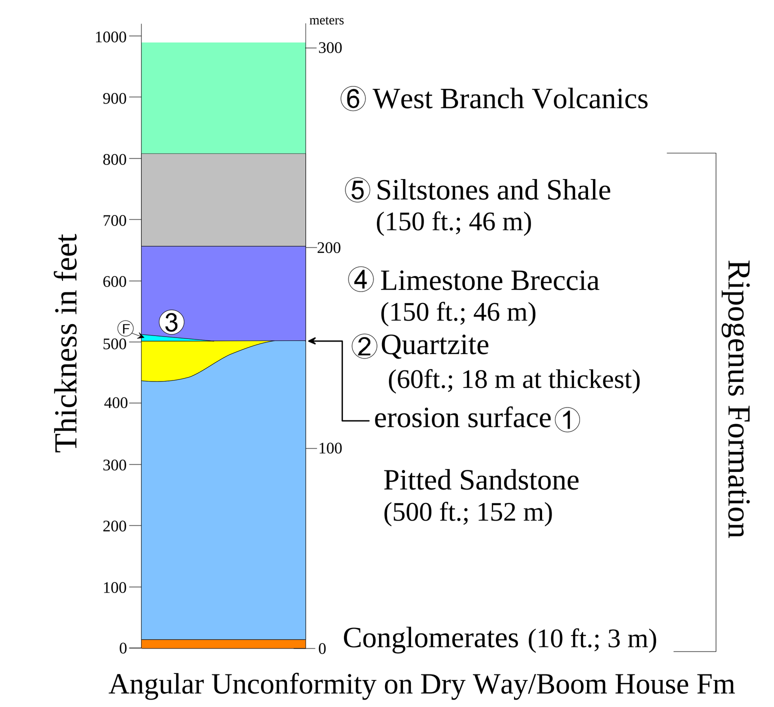
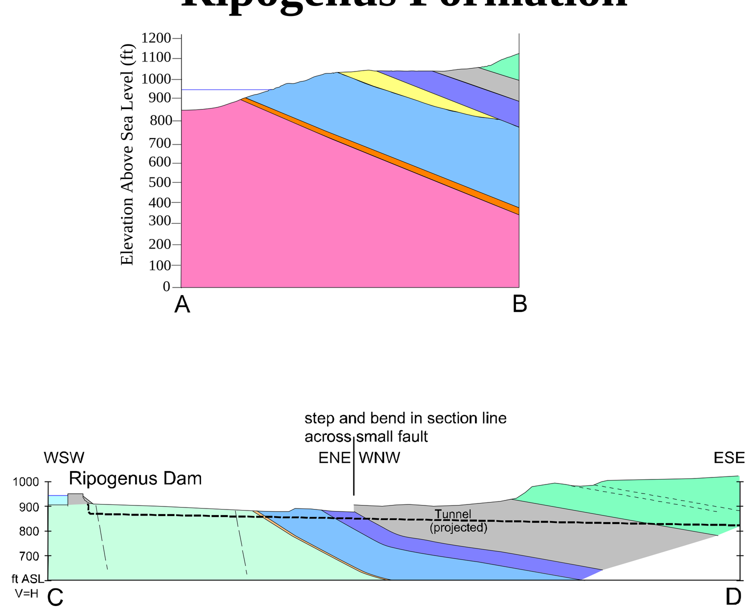


Fig. 3. Cross-sections of the Ripogenus Formation



Stratigraphy (continued)

Mudrocks and Siltstones ⑤

Overlying the breccia unit are mudrocks containing planar-bedded laminae of quartz-arenite siltstones. These fine grained beds in the west part of this area have a red/purple coloring, and are in part calcareous, and contain a weak slaty cleavage, but they become grey to greenish flinty hornfels in the gorge of the West Branch Penobscot River due to proximity to the Katadhin Granite. We interpret these sediments to have been deposited below wave base, and perhaps to be contourites, and to signify further rapid subsidence. This unit forms the top of the Ripogenus Formation.

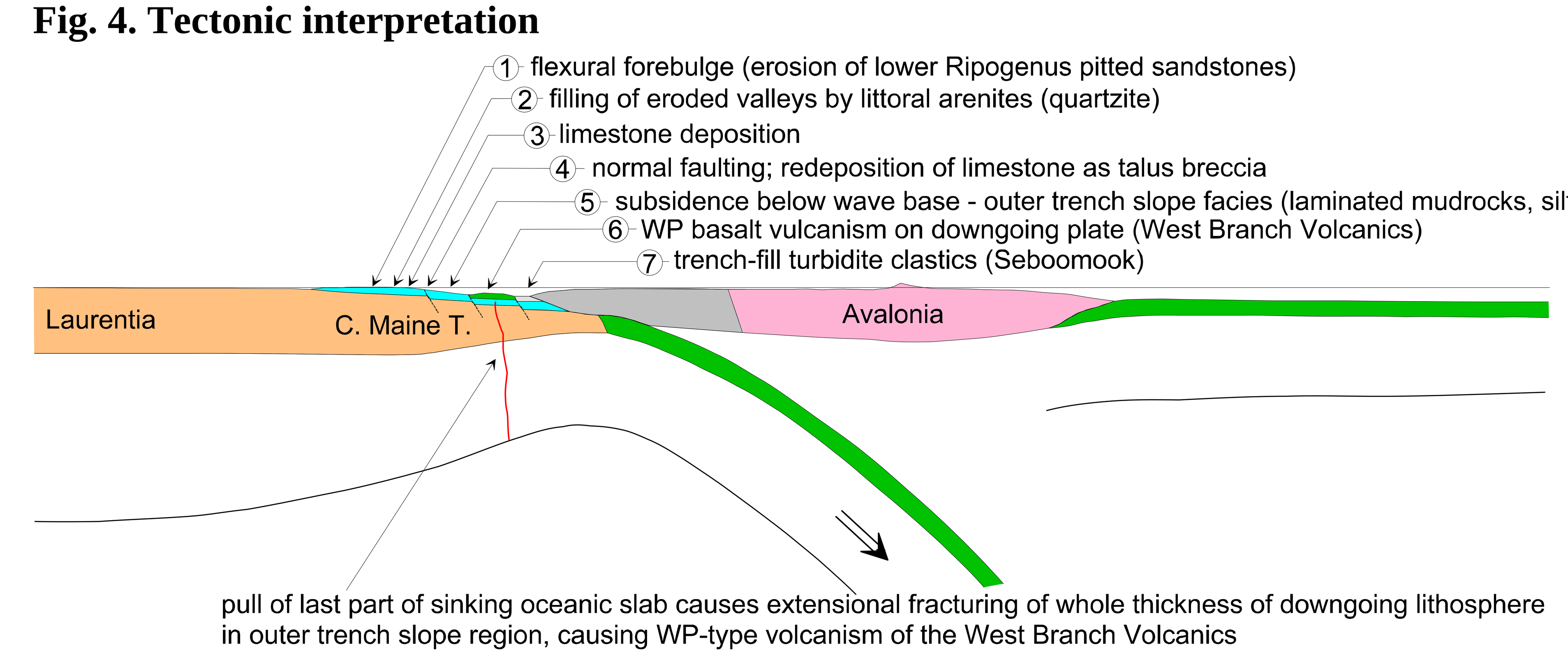
West Branch Volcanics; Seboomook Fm ⑥ ⑦

Basaltic lava flows, in part pillowed, overlie the mudrock/siltstone member at the top of the Ripogenus Formation. Some of the tabular mafic units in the West Branch could have been intruded as shallow sills. A minor proportion of the section consists of mudrocks/siltstones identical with those under the volcanics. The basalt geochemistry shows clear evidence for a within-plate ("non-plate-boundary") source. Local andesite compositions are from crustal contamination, not from a subduction origin, and the total lack of fragmental volcanic products in the section also argues against this. The kilometer-scale thickness of these volcanics also implies continued, and perhaps further increased, rapid subsidence. Overlying turbidite clastics of the Seboomook Fm. also support this notion, and imply that the volcanics were erupted before the descending, subsiding plate reached the Acadian trench where the deposition of those turbidites was localised (Bradley et al, 2000).

Tectonics - see Fig. 4.

Following Bradley et al, 2000, we place Silurian-Devonian events recorded in the central Maine region in the context of the Acadian convergence and collision. We interpret the erosion surface we document here as a record of flexural forebulge passage through the former Silurian shelf strata, and the sedimentation after as a record of increasingly rapid subsidence on the outer slope of a trench-like feature created by the convergence where underthrusting was to the southeast. We think that normal faulting, perhaps caused by flexural extension of the lithosphere, was responsible for creating the limestone breccia unit. Mafic volcanism of within-plate type (the West Branch Volcanics) however, likely requires extension and local failure of the whole lithospheric thickness of the downgoing plate. We think this was caused by stresses imposed by the old, cold sinking slab of mantle lithosphere attached to the downgoing plate. The slightly younger, much more voluminous magmatism of the Moxie/Katadhin/Traveler event could have a similar origin, with extensive induced crustal melting.

Fig. 4. Tectonic interpretation



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