Definition, Problems, and Reinterpretation of Early Premetamorphic Faults in Western Maine and Northeastern New Hampshire

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ABSTRACT

Faults that originated prior to tight Acadian folding and formation of slaty cleavage are fundamental structural elements of the northwest limb and axial zone of the Kearsarge-central Maine synclinorium. They occur mainly, but not entirely, southeast of the Silurian tectonic hinge that marks the northwest margin of the synclinorium’s ancestral sedimentary basin. The faults, termed early premetamorphic faults, commonly excise more than 3 km of section. Because the faults are almost cryptic in outcrops and are difficult to recognize, they have been controversial since three were first described in 1970. The following major early faults and associated features are now recognized in western Maine and adjacent New Hampshire. (1) The Hill 2808 and Mahoosuc faults are interpreted as a single basin-margin, southeast-down normal fault. (2) The Barnjum fault is an inferred southeast-down normal fault contained southeast of the hinge within the Silurian-Devonian basin sequence, but postulated to flatten northwestward across the hinge where it dislodged the shoreward facies of these deposits approximately along their basal unconformities. The gabbroic Sugarloaf pluton is inferred to have been emplaced as a thin sheet along part of the gently dipping portion of the fault. Smaller gabbro bodies also occur along or near other early faults. (3) The Plumbago Mountain fault, also within the northwest limb of the synclinorium, is interpreted as a steeply dipping, southeast-down normal fault near its northeast end, but as a gently dipping rupture farther southwest, where it is sinuous in plan, owing to younger deformation. In the Mahoosuc Range, New Hampshire, the Plumbago Mountain fault outlines a large inferred window containing small, synclinal, inferred outliers. (4) The Blueberry Mountain and Winter Brook faults are inferred to mark the margins and sole of the Rumford allochthon, a 30 × 70 km feature mapped in the axial zone of the Kearsarge-central Maine synclinorium. Within the allochthon is the Bald Mountain fault, interpreted as an internal rupture. The faults cut early folds, but, on the basis of geometric relations between fold plunges and fault displacements seen near the ends of the Hill 2808 and Barnjum faults, early faulting and folding are interpreted to have been contemporaneous.

On the basis of the distribution of inferred outliers and windows, we interpret the Plumbago Mountain, Blueberry Mountain, and Winter Brook faults to delineate younger-over-older features. An older-over-younger thrust interpretation is not ruled out, however, because the windows of our interpretation can be turned “inside out” to form outliers without changing map patterns. The alternate thrust interpretation requires probably several tens of kilometers of horizontal transport that should be expressed by the juxtaposition of different sedimentary facies, but no major facies juxtapositions are seen. Our preferred younger-over-older interpretation is satisfied by relatively small horizontal displacements.
The early faults and folds are postulated to have formed by giant-scale slumping into the ancestral sedimentary basin. On the basis of abrupt thickening of Silurian units on the southeast sides of the Hill 2808 and Barnjum faults, slump-faulting and folding probably began in Silurian time; it culminated, however, after deposition of the Lower Devonian Seboomook Formation but prior to Acadian compression. Culmination might have been triggered by emplacement of gabbroic magma along or near the faults.

INTRODUCTION

During his 1961-65 mapping in the Phillips, Rangeley, and Rumford 15-minute quadrangles, Moench (1970, 1971, 1973) delineated three major but almost cryptic longitudinal premetamorphic faults, shown as the Hill 2808, Barnjum, and Blueberry Mountain early premetamorphic faults on Figure 1a. Within the area that was mapped at that time, Moench (1970, Figs. 2, 10; 1973, Fig. 4). A similar relationship is exposed in relation to the Barnjum fault. On this basis Moench (1970) inferred that a genetic relationship exists between faulting and folding. He further postulated that the entire major fault-fold cleavage pattern originated by slumping into the ancestral sedimentary basin, and that slumping was accompanied by tectonic dewatering (Moench, 1970, Fig. 14, p. 1488-1492; 1973, Fig. 5, p. 336-339).

Since then, mapping has been completed or revised at 1:62,500 through a much larger area (Osberg et al., 1985; Moench et al., 1982; Moench and Pankiwskyj, 1988; Moench, 1984), and three additional premetamorphic early faults have been mapped, shown as the Mahoosuc, Plumbago Mountain, and Winter Brook early premetamorphic faults on Figure 1a. As a result, we now have a much-improved grasp of how the faults relate to the geologic framework and paleotectonic setting of a large region, and a better basis for addressing controversial aspects of the faults. Some of our colleagues have expressed disbelief of some (or all) early faults, on the grounds that the stratigraphic units on opposite sides were incorrectly identified. Others have challenged the inferred younger-overolder relationships and the postulated down-to-basin slump origins.

Finally, since the early 1970's, John Maxwell's dewatering hypothesis for the origin of slaty cleavage (Maxwell, 1962), applied by Moench (1966, 1970, 1973) to western Maine, has been largely supplanted by the multi-authored pressure-solution hypothesis (see discussions and examples in Borradaile et al., 1982). Accordingly, whereas Moench previously invoked a model of basin-controlled slumping and tectonic dewatering without major orogenic compression, he now favors a mechanism of pre-Acadian, basin-controlled, slump-faulting and open-folding, but followed by Acadian compression, which deformed the faults, greatly tightened and amplified the folds, and produced the slaty cleavage.

Readers are referred to Moench et al. (1987) and Moench (in press) for discussions of the newly-recognized Piermont allochthon of northwestern New Hampshire and adjacent areas. The Piermont allochthon is pertinent to this paper because it is interpreted as an Acadian thrust sheet whose contents accumulated on a postulated Silurian platform along and immediately northwest of the Silurian tectonic hinge of Figure 1b. The platform is proposed to have been compressed almost out of existence by Acadian compression.

The focus of this paper is on the stratigraphic and structural features that bear on the interpretation of the mapped early faults. The paper is an outgrowth of published mapping, the cited early papers, several talks, and a guide article that was prepared for a Maine Geological Society field trip that was run on July 28, 1985. Figure 1 is simplified from the maps of Moench et al. (1982), Moench and Pankiwskyj (1988), and Moench (ed.), (1984). Readers are referred to these published maps for sources of detailed information and mapping credits. We are grateful to Dwight Bradley, Bob Marvinney, and Phil Osberg for their constructive reviews.

STRATIGRAPHY

The area of Figure 1 is underlain by 7-8 km of Lower Devonian and Silurian metasedimentary strata, and by 5 km or more of Cambrian? to Ordovician metasedimentary and metavolcanic rocks. These rocks have been divided into many formations which, for simplicity, are grouped on Figure 1 into six sequences according to age. The thin Silurian shelf and shoreline facies are singled out to illustrate part of the southeastern margin of the Silurian source area. Brief descriptions of units are provided in the map explanation. A synthesis of sedimentation is provided in the pamphlet that accompanies the geologic map of western interior Maine (Moench and Pankiwskyj, 1988). As shown on the index to Figure 1, the area spans most of the Kearsarge-central Maine synclinorium, but it overlaps the north end of the Bronson Hill anticlinorium and the southeast side of the Boundary Mountains anticlinorium.

The Silurian tectonic hinge (Fig. 1b) is the approximate axis of abrupt northwestern thinning from about 5 km of Silurian clastic deposits of a conformable basin sequence southeast of the hinge to much thinner shelf and shoreline deposits to the northwest (Moench and Boudette, 1987; Hatch et al., 1983).
Northwest of the hinge, lower contacts change from conformity to unconformity. Whereas only a Silurian graptolite fauna is known in the basin sequence (Pankiwskyj et al., 1976), Silurian deposits northwest of the hinge locally contain a varied, relatively shallow-water shelly fauna (Boucot and Thompson, 1963; Boucot and Heath, 1969; Moench and Boudette, 1970). As already noted in the introduction, Moench (in press) has proposed that the interval between the hinge and the shelf-shore facies was a wide Silurian platform, with sub-basins.

The Silurian tectonic hinge is expressed most conspicuously by the Lower Silurian Rangeley Formation, which thins from about 3 km south of Rangeley village to about 1/2 km in the Kennebago Lake area. Upper Silurian shelf or shoreline facies with disconformable or unconformable lower contacts northwest of the hinge are represented by the Fitch Formation of western New Hampshire (Billings, 1956), the Hardwood Mountain Formation of the Moose River synclinorium, northwestern Maine (Boucot and Heath, 1969), and The Forks Formation (upper Silurian?) at the northeast corner of Figure 1a (Marvinney, 1984). These units are approximately equivalent to the Madrid Formation of the basin sequence. Lower Silurian shelf facies are represented by fossiliferous quartz conglomerate and calc-silicate rock of the Rangeley Formation (basal member C) within the northeastern end of the Kennebago outlier, where the lower contact is faulted, and outside the outlier just southeast of Kennebago Lake, where underlying Silurian deposits are conformable but thin (Moench and Boudette, 1970, 1987). Lower Silurian shoreline facies are represented by massive, lenticular-bedded orthoquartzite and quartz conglomerate assigned to the Clough Quartzite (Moench and Boudette, 1987) along the northwest margin of the Kennebago outlier, mapped both inside and outside the allochthon (Fig. 1a,b). Exposures of Clough Quartzite near the northwest side of the allochthon are underlain by a thin unit of pelitic rocks, probably member B of the Rangeley Formation; northwest of the allochthon these deposits rest unconformably on pre-Silurian rocks. The lower contact of the type Clough Quartzite in western New Hampshire is an unconformity (Billings, 1956).

In areas of low- to high-grade metamorphism, but not including the migmatitic gneisses (Fig. 1b), bedding is well preserved and provides the basis for defining formation characteristics and younging directions, and the stratigraphic omissions and truncations produced by the early faults. The actual faults, however, are very inconspicuous in outcrop (Moench, 1970, Figs. 7-9, 12, 13) and can be missed if careful attention is not paid to the differences between individual rocks and sequences of rocks on both sides. It is emphasized that widely separate parts of the stratigraphic section may be remarkably similar (for example, pelitic parts of the Rangeley and Carrabassett Formations) and can be misidentified if the sequence from one unit to another, if exposed, is not recognized. This is a particularly difficult but not unsolvable problem in areas of migmatitic gneiss. Although detailed bedding features and sedimentary evidence of younging directions are lost in areas of migmatitic gneiss, the large sequences can be seen and are identified accordingly on Figure 1a. (See Moench and Hildreth, 1976, and Moench and Pankiwskyj, 1988, for descriptions of the migmatitic gneisses.)

**STRUCTURAL AND METAMORPHIC CHRONOLOGY**

The complex structural and metamorphic pattern of western Maine is the product of events that produced the early faults and associated folds, followed by Acadian compression and subsequent plutonism. A chronology that accords with our interpretation of known relationships and available isotopic age data includes the following events:

1) Early faulting and associated open folding: Early faults and folds are inferred to be coeval; their origin was possibly accompanied by incipient development of slaty cleavage by tectonic dewatering, but no major metamorphism, with the possible exception of areas near gabbroic intrusions that were emplaced along early faults, particularly the Sugarloaf pluton along the Barnjum early fault. Earliest movements probably accompanied Silurian sedimentation and the latest movements occurred after deposition of the Lower Devonian Seboomook Formation. The age of the Sugarloaf pluton, approximately dated at 406 ± 12 Ma (data in Moench, 1984; K-Ar biotite method), suggests that latest movement on the Barnjum fault occurred no later than about 405 Ma.

2) Acadian compression: This compression caused tight folding, formation of slaty cleavage, and greenschist-facies or lower-rank metamorphism (M1). This event greatly tightened and amplified the early folds, produced new folds, and deformed the early faults. This probably occurred between about 405 and 400 Ma, as shown by truncation of Acadian folds and cleavage by the Lexington batholith, dated at 399 Ma (Gaudette and Boone, 1985; Gaudette, pers. commun., 1985; Rb-Sr whole-rock (399 ± 6 Ma) and mineral (399 ± 3 Ma) isochrons).

3) Localized, overlapping multiple deformation and metamorphism produced by post-Acadian Devonian to Carboniferous plutonism: This produced the metamorphic zoning and many of the mapped structural "twists and turns" shown on Figure 1. The tie between the origin of superposed folds, late schistosity, metamorphic zoning, and the emplacement and cooling history of the Mooselookmeguntic batholith and other plutons has been demonstrated by Moench and Zartman (1976) on the basis of structural and petrographic observations. The metamorphic zoning of Holdaway et al. (1982) is similar in principle, but different in application. Each new thermal event can be labeled according to M1, M2, and so on, where 1 is the regional Acadian event, and n is each successive plutonic emplacement; chronology cannot be completed until all major plutons are dated. The oldest recognized metamorphism (M1) and deformation was produced by the 400 Ma Lexington batholith and possibly the Redington and Phillips plutons. An intermediate dynamothermal event was produced by two-mica granite of the Mooselookmeguntic batholith, dated at 371 ± 6 Ma (Moench and Zartman, 1976; Rb-Sr whole-rock; new constants). The youngest known high-rank dynamothermal pattern is related to the Carboniferous Sebago batholith in southwestern Maine (south of area of Figure 1).
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PLUTONIC ROCKS

Devonian rocks - Dm, mafic; Dr, felsic and intermediate

Ordovician rocks - Om, mafic; Of, felsic

STRATIFIED METAMORPHIC ROCKS

Lower Devonian
Younger sequence - Schoenrock Fm, mainly gray pelitic schist and graded metasandstone. Lower contacts conformable.

Older sequence - Hildreths, Carrabassett, Littleton Fms. Hildreths: volcaniclastic metagraywacke, calc-silicate rock; Carrabassett: massive gray pelitic schist; Littleton gray pelitic schist, metasandstone. Lower contacts conformable.

Silurian and Silurian?

Silurian and Silurian?
Younger sequence - St. Clough. Quartzite: orthoquartzite and quartz conglomerate. Lower contact unformamtable. Smc, Rangeley Fm, mbr C: shelf facies; sandstone, fosiliferous quartz conglomerate and calc-silicate rock. Spr, Perry Mountain and Rangeley Fms. Perry Mountain interbedded pelitic schist, quartzite; Rangeley: gray sulfidic schist, metasandstone with quartz metaglomerate (mbr C5), quartz-rich polymictic conglomerate (mbr B1), polymictic boulder to pebble conglomerate, meta-arkose (mbr A). Lower contacts conformable. Ssa, Sangerville Fm: green to gray pelitic schist, volcaniclastic metagraywacke, fine grained metaglomerate, thinly banded metagraywacke. Lower contact conformable.

Lower Silurian? and Upper Ordovician?
Transitional sequence - Greensville Cove and Quimby Fms. Greensville Cove: laminated feldspathic meta sandstone, metasandstone, calc-silicate rock. Quimby: gray to black sulfidic schist, volcaniclastic metagraywacke, lower felsic metavolcanic rocks. Contacts conformable.

Middle Ordovician, Lower Ordovician, Upper Cambrian?
Ammonoosuc: Volcanics, Partridge and Dead River Fms. Ammonoosuc: basaltic metavolcanic and related metasedimentary and exhalative rocks. Lower contact possibly unformamtable. Partridge: black sulfidic schist or slate, minor greenstone. Intertongues with Ammonoosuc; Dead River: thinly interbedded pelitic schist, quartzite.

Figure la. Simplified geologic map of western Maine and adjacent New Hampshire showing stratigraphic and plutonic units, and distribution of early premetamorphic faults. Modified from Moench and Pankiwskyj (1988) and Moench (ed.), (1984).
Early premetamorphic faults, western Maine

Contact

Late premetamorphic or postmetamorphic fault – Undivided

Early premetamorphic fault – Barbs on downthrown side, or on side of upper plate; queried where conjectural; dotted where correlated across plutons. Named faults: MF, Mahoosuc; 117F, Hill 2800; BIF, Blueberry Mountain; PMF, Plumbago Mountain; BMF, Blueberry Mountain; BDF, Bald Mountain; WB1, Winter Brook.

Metamorphic facies – Barbs on side of higher rank. GS, green schist; ELA, epidote-amphibolite, low-rank amphibolite; MHA, medium and high-rank amphibolite.

Area of migmatitic gneiss – Evidence of partial melting, bedding commonly destroyed; calc-silicate-rich units particularly disrupted.

Silurian tectonic hinge – Approximately located; arrow points toward thick Silurian basin facies.

Figure 1b. Metamorphic isograds, pluton names, allochthons, and geographic names for same area as (a).
HILL 2808 AND MAHOOSUC EARLY FAULTS

These features mark significant parts of the boundary between pre-Silurian and Siluro-Devonian rocks and are inferred to correlate across the Mooselookmeguntic batholith. This correlation is based on the structural and stratigraphic continuity seen in roof pendants of the batholith. The two faults have somewhat different characteristics, however, which are here interpreted in terms of different depth environments.

The Hill 2808 early fault dips 50-68 degrees southeast, as measured at four outcrops (Moench, 1971), and younger rocks on the southeast are faulted against older rocks on the northwest. These relationships indicate that it is a normal fault. The fault ends at the southeast corner of Rangeley Lake, and it is truncated on the southwest by the Mooselookmeguntic batholith.

The location of the important sequences that demonstrate the existence of the fault are shown in Figure 2 (areas la and lb); detailed descriptions are provided by Moench (1970, p. 1475-1482; 1971). Area la is in the garnet and retrograded staurolite metamorphic zones. The sequence includes the Quimby Formation and type localities of the Greenvale Cove and Rangeley Formations, along and near Maine Highway 4, 1.5 to 3.5 miles south of Rangeley (Moench and Boudette, 1987). Here, an apparently unfaulted, southeast-younging sequence approximately 3-3.5 km thick is exposed across the northeastern terminus of the Hill 2808 fault. The rocks include the upper part of the Quimby Formation (1 km thick), the Greenvale Cove Formation (200 m thick), and three members of the Rangeley Formation (total about 3 km thick).

Structurally, the sequence at area la (Fig. 2) constitutes the northwest limb of the Mountain Pond syncline; this limb is truncated farther southwest by the fault. Near the arrow within the northwest limb of the syncline (Fig. 2), minor folds plunge 30-70 degrees to the southwest (Moench, 1971). This is the area of most abrupt loss of section toward the southwest along the fault. Farther southwest, plunges become gentler and loss of section is more gradual; here it takes place mainly by truncation of northeast-plunging, folded, pre-Rangeley strata northwest of the fault. Near the arrow at the nose of the Brimstone Mountain anticline, due southeast of the steepest southwest plunges of the Mountain Pond syncline, minor folds plunge 10-30 degrees northeast. Again, plunges become gentler farther southwest.

Area lb (Fig. 2) lies astride the sillimanite isograd of the Mooselookmeguntic batholith. The important stratigraphic sequence is along the crest and steep eastern slope of Hill 2808 (Moench, 1971). Here, the uppermost beds of the Rangeley Formation (member C) are faulted against the uppermost beds of the Quimby Formation; approximately 3.5 km of strata are missing. The Quimby Formation, exposed in a narrow, northwest-younging belt just northwest of the fault, is over lain to the north-west by the Greenvale Cove Formation, which is exposed in a syncline that is truncated by the fault to the southeast. Although graded beds top southeast within two or three meters of the fault, the larger sequences on both sides of the fault (about 400 m) top to the northwest, as indicated on the face of Figure 2.

As seen in outcrops in area lb and thin sections, the fault is a sharp, pre-cleavage feature that shows evidence of sand-
stone disaggregation and mixing (Moench, 1970, Figs. 7-9, esp. 9b) but no conspicuous evidence of cataclasis. The wall rocks appear to have been poorly lithified during faulting.

The fact that the most abrupt southwestward loss of section along the fault coincides with the steepest southwest plunges within the syncline to the southeast and with the steepest northeast plunges within the anticline farther southeast is evidence that the fault and folds are temporally and dynamically related. The Mountain Pond syncline may be called a hanging-wall syncline, and the fault and both folds to the southeast may be called a fault-fold unit (Moench, 1973).

It is further noteworthy that member A of the Rangeley Formation, composed of metamorphosed sandstone and conglomerate, is much thicker (1.2 km) southeast of the Hill 2808 fault than it is anywhere to the northwest or to the southeast of the crest of the Brimstone Mountain anticline. By analogy with Gulf Coast structure (Moench, 1970, 1973), the fault may thus have begun to form in the Silurian as a growth fault. The Brimstone Mountain anticline is inferred to have begun to form as a rollover, by back-tilting toward the hanging wall of the presumably listric Hill 2808 normal fault. The Mountain Pond syncline may have formed by a combination of back-tilting on the northwest limb of the anticline and drag adjacent to the fault. During the Acadian, both folds were greatly tightened and overturned slightly to the northwest. If the fault originally dipped moderately, say 60 degrees, southeast, it would have been steepened by horizontal compression, but overturning would have had the opposite effect.

The Mahoosuc early fault juxtaposes the Rangeley, Perry Mountain, and Littleton Formations on the southeast against the Dead River and Partridge Formations, the Ammonoosuc Volcanics, and Ordovician granite (Fig. 1a). For a distance of about 13 km northeast of the state line, the Mahoosuc fault contains an inferred slice of extremely rodded polymictic, boulder- to pebble-metaconglomerate assigned to member A of the Rangeley Formation. The clasts, which include metamorphosed volcanic, sedimentary, and granitic rocks, and vein quartz, are round to sliver-like in plan view, but they are rodded almost vertically (consistent plunge about 80 degrees NE). The rodding might be Acadian, however, because less extreme conglomerate rodding of similar orientation is seen well away from known early faults.

Although the metaconglomerate might be interpreted to rest unconformably on pre-Silurian rocks, features seen at one outcrop indicate that its northwestern contact is a premetamorphic fault. The outcrop is in a brook at elevation 1860 ft, about 2,000 ft (600 m) S17°E of the top of Deer Hill in the Old Speck Mountain 15-minute quadrangle. Here, a bed of metaconglomerate about 3 m thick youngs northwest, as shown by normal grading, and is sharply juxtaposed at its top against rusty-weathering, black, sulfidic schist and metasiltstone of the Partridge Formation, which also youngs northwest. The contact is knife-sharp, shows no evidence of cataclasis, and is crossed by schistosity.

The following are other important characteristics of the Mahoosuc fault. 1) A zone as much as 1/2 km wide of sharply interlaminated feldspathic quartzite and pelitic schist extends along the southeast side of the metaconglomerate slice; granoblastic textures are seen in thin sections. This zone, interpreted as extremely flattened Rangeley and Perry Mountain Formations, might have originated by an unknown process during normal faulting; alternatively, it might be a product of buttressing of viscoplastic Silurian rocks against more competent pre-Silurian rocks during Acadian compression. 2) Several small bodies of metamorphosed gabbro, now amphibolite, are exposed along the fault or nearby within the hanging wall.

If the Hill 2808 and Mahoosuc early faults are correctly correlated across the Mooselookmeguntic batholith, they represent a single feature that extends at least 100 km along the boundary between pre-Silurian and Siluro-Devonian rocks in western Maine and northern New Hampshire. Noting that the fault lies close to or on the approximate trace of the Silurian tectonic hinge, Moench (in press) proposed that it is a major, basin-margin normal fault. As such, it was probably active in Silurian time; its latest movements, however, occurred after the early Devonian formation of the Plumbago Mountain early fault, which is truncated by the Mahoosuc fault. Under this interpretation, the Hill 2808 segment is inferred to represent a relatively shallow expression at the northeastern extremity of the fault. At the present level of exposure, the wall rocks of the Hill 2808 fault were semilithified. Farther southwest, deeper levels of penetration are represented where the fault cuts hard pre-Silurian granite. The rather straight trace of the entire length of the Mahoosuc-Hill 2808 fault indicates that it originally dipped rather steeply and penetrated to deeper levels than the Blueberry Mountain, Plumbago Mountain, and Winter Brook faults, whose traces are extremely sinuous.

**BARNJUM EARLY FAULT, GABBROIC INTRUSIONS, AND KENNEBAGO OUTLIER**

The Barnjum fault extends from about 3 km northwest of Madrid village at least to the south end of the gabbroic Sugarloaf pluton (Fig. 1a, b). In a manner that is analogous to the Hill 2808 fault and associated folds, the Barnjum fault is interpreted to be a normal fault, southeast side down. The southwest end of the fault is about 3 km northwest of Madrid village; displacement increases northeastward in the direction of plunge of a prominent hanging-wall syncline and is greatest at the south end of the Sugarloaf pluton, where the Carrabassett Formation is juxtaposed against the Perry Mountain Formation; the Smalls Falls and Madrid Formations have been excised. The fault cannot end at its point of maximum displacement, however, where two formations and unknown amounts of two others are missing. Because no evidence of displacement is seen on-strike immediately to the northeast, the Barnjum fault is inferred to project northward, as shown, across the Sugarloaf pluton. The Sugarloaf pluton, a rather thin (< 1 km) gently dipping sheet (Carnese, 1981; Carnese et al., 1982), intervenes between northeast-trending belts of Ordovician and Silurian rocks to the southwest and a hook-shaped belt of conformable Lower Devo-
nian formations to the northeast. Southeast of Stratton, parts of the Carrabassett, Hildreths, and Seboomook Formations exposed in the hook-shaped belt lie discordantly above the Dead River Formation. Here, all of the transitional and Silurian sequences are missing (Fig. 1a,b). Although Boone (1973, Fig. 7) has interpreted these relationships in terms of stratigraphic onlap across a regional unconformity, we prefer the fault interpretation because several different formations are juxtaposed on both sides of the boundary, or would be if the Sugarloaf pluton were removed.

We propose that the Sugarloaf pluton was emplaced along the flattened, northern extension of the Barnjum fault, as shown above ground in section A-A' (Fig. 1b). Boone (1973) has shown that the Sugarloaf gabbro is older than the granitic Lexington batholith, in accord with the isotopic age data already cited. Permissively, the gabbro might have intruded while the Barnjum fault was active.

It is tempting to correlate the Barnjum fault with the lower contact of the Kennebago outlier of Silurian rocks (Fig. 1a,b). The outlier is an open, synclinal body that contains Early Silurian inferred shoreline deposits of the Clough Quartzite (Moench and Boudette, 1987, p. 275-277) along its north side, and fossiliferous Early Silurian shelf metasiltstone near its eastern end. The Clough Quartzite, underlain by a thin unit of dark slate, also occurs in outliers, too small to show on Figure 1, just northwest of the Kennebago outlier. The Clough Quartzite of the Kennebago outlier is overlain by slate and metasandstone of the Rangeley (member C) and Perry Mountain Formations. Because the Clough Quartzite (and a body of Rangeley polymictic conglomerate exposed at the southwest end of the outlier) is exposed at or near the lower boundary of the outlier, this boundary can be interpreted as a major unconformity. The boundary, however, truncates almost at right angles across a steeply dipping, southeast-younging sequence that contains, immediately southeast of the outlier, conformable beds of the Greenvale Cove and Rangeley Formations. At this locality, the Rangeley Formation is thin (less than 500 m), but all three members are represented (Moench and Boudette, 1987, p. 275-277), including fossiliferous quartz conglomerate and metasiltstone in member C.

Tentatively, we propose that the lower contact of the Kennebago outlier is a fault, because it is difficult to reconcile the close juxtaposition of rocks that lie above a right-angle unconformity with rocks of the same age that lie within a conformable sequence. On the assumption that the Kennebago outlier is allochthonous, we favor a model of southeastward sliding, rather than northwestward thrusting, in order to place the site of a major Silurian unconformity farther northwest from the known Silurian conformity.

We favor an interpretation in which the Barnjum early fault has an approximately cymoid shape in cross section, approximately as depicted on Figure 1b (section A-A', and northwest end of section B-B'). According to this interpretation, north of the Redington and Sugarloaf plutons it is sub-horizontal, though broadly warped, and marks the sole of a widespread allochthon composed of gently folded Silurian and Lower Devonian units that were deposited perhaps several kilometers farther northwest. We infer that it dislodged these deposits along or near the basal unconformities, and that it passed southeastward into the thick basin sequence. If, contrary to our belief, the Kennebago outlier is autochthonous, the fault may have originated within the Devonian sequence north of the area of Figure 1 and sliced downward through thin Silurian deposits to the pre-Silurian sequence exposed below the fault southeast of Stratton.

Near the southeast sides of the Redington and Sugarloaf plutons, the fault is inferred to roll southeastward to a steep southeast-asterly dip; farther southeast it is inferred to flatten in depth and disappear with diminishing displacement within the thick basin sequence. Displacement also diminishes southwestward to zero west of Madrid village (Fig. 1a,b). According to our interpretation, the fault is a flat-lying detachment feature in northwestern areas, attached in the southeast, and originated much as a rug might slide down an incline, when nailed to the lower edge and one side of the incline. The fault was a locus for the intrusion of gabbroic magma which, speculatively, might have triggered movement.

The fault-fold relationships exposed along the segment of the Barnjum fault that lies between Madrid and the Sugarloaf pluton suggest that faulting began by a listric growth-fault mechanism, as proposed for the Hill 2808 fault and related folds. The fact that the thickest known deposits of the Silurian Smalls Falls Formation (composed of strongly sulfidic-graphitic, closed-basin deposits of types that are common in extensional basins) are exposed between the fault and Madrid village, and that the Smalls Falls Formation thins abruptly to the north across the fault, suggests that Barnjum faulting began during the deposition of the Smalls Falls Formation.

Osberg et al. (1985) depict the Barnjum fault southeast of the Redington and Sugarloaf plutons as a normal fault, southeast side down (section F-F'), and they show southeast transport on the fault between the Devonian and pre-Silurian sequence just east of Stratton (section E-E'), in approximate accord with our interpretation. Unlike the interpretations by Osberg et al. (1985), our model attempts to relate these features as a single surface of dislocation. We favor southeast transport by gravity sliding, as opposed to northwest-directed thrusting, because southeastward normal displacement more easily explains the presence of younger rocks on the southeast side of the fault, where mapped south of the Redington pluton, as well as the relation between fault displacement and synclinal plunge in that area. A thrust model would require that the fault cut down-section in the direction of transport and cannot explain the plunge-displacement relationships.

PLUMBAGO MOUNTAIN EARLY FAULT

The northeast end of the Plumbago Mountain fault is mapped about 7 km southwest of Madrid village, where northwest-younging rocks of the Madrid and uppermost Smalls Falls Formations abut northwestward against southeast-younging basal
rocks of the Smalls Falls Formation (Moench, 1971); here, about 700 m of strata are missing. Displacement increases to the southwest, where the fault is mapped in and out of the septum between the Mooselookmeguntic batholith and the Bunker Pond pluton, and from there almost to Gorham, New Hampshire, for a total length of at least 70 km. Regionally, younger rocks on the southeast abut older rocks on the northwest, but this relationship is modified greatly by younger folding along the southwestern segment of the fault; there, structural relationships suggest that younger-over-older relationships occur vertically across a sub-horizontal dislocation. These relationships suggest that the fault originated as a southeast-down normal fault. It was probably listric, with a steep original dip near its northeast end and a gentle dip west of Rumford.

Outcrops of the Plumbago Mountain fault were found: 1) at an elevation of 2280 ft on the north shoulder of Plumbago Mountain, about 630 ft (250 m) west of the boundary between the Rumford and Old Speck Mountain quadrangles, Maine; 2) at an elevation of 1860 ft on the southeast side of an unnamed hill, 11,800 ft (3300 m) azimuth N60°W from the southeast corner of the Old Speck Mountain 15-minute quadrangle; and 3) at an elevation of 1600 ft in a tributary to Peabody Brook, near the west side of the Shelburne 7.5-minute quadrangle, New Hampshire; the outcrop is about 1300 ft (400 m) southwest of Giant Falls, which is labeled on the quadrangle map. At all localities the fault can be placed within a few centimeters, shows no evidence of cataclasis, and can easily be mistaken for a sharp normal contact.

The relationships shown on the face of Figure 3 (near the indicated younging directions) correspond to sequences exposed at North Newry (Fig. 1a,b) along the Bear River and Highway 26 in the Old Speck Mountain quadrangle. The rocks are in the sillimanite zone, but they are well bedded and display primary features. The fault surface can be placed within a few meters, but is not exposed. The Rangeley Formation north of the fault youngs north (left on Fig. 3), as shown by graded bedding. Here, member B of the Rangeley Formation, composed of dark, rusty-weathered pelitic schist, metasandstone, and polymictic metaconglomerate, is overlain to the north by member C, composed of schist, metasandstone, and quartz metaconglomerate. South of the fault is a south-younging sequence that includes two members of the Madrid Formation (thinly-bedded, calc-silicate rock overlain by thickly-bedded, feldspathic metasandstone and gray pelitic schist), and the Carrabassett Formation (gray pelitic schist showing faint to conspicuous cyclic graded bedding).

The top of the block (Fig. 3) corresponds to the map pattern in nearly 70 square km across the boundary between the Rumford and Old Speck Mountain quadrangles. The sinuous trace of the fault is produced by a late synform-antiform pair thought to plunge southwest at a low angle. Because of complex intersecting deformation, however, the actual plunge of this feature is unknown, and probably cannot be determined by studies of minor folds. The simplest interpretation of this feature is that the fault originally dipped gently southeastward and was later warped to produce the observed map pattern. It is noteworthy that if the upper plate of Lower Devonian rocks were removed, the Rangeley-Perry Mountain Formation contact that is mapped within the antiform in the Old Speck Mountain quadrangle prob-

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Figure 3. Block diagram showing inferred structure of the Plumbago Mountain early fault and truncation of formations in the upper and lower plates. Old Speck Mountain and Rumford quadrangles. Location shown on Fig. 1b.
ably would connect northeastward across the synform to the same contact mapped just east of the quadrangle boundary. The strong discordance between the upper and lower plates indicates that the fault cuts early folds.

The Plumbago Mountain pluton (Fig. 3) is a layered mafic-ultramafic body inferred to have been emplaced along the Plumbago Mountain fault. A sheet of metagabbro lies along the fault on the southeast side of the synform.

In the Mahoosuc Range, northeast of Gorham, New Hampshire, (Fig. 4) is an inferred window, here called the Mahoosuc window, that exposes parts of the Rangeley and Perry Mountain Formations through structurally overlying rocks of the
Madrid and Littleton Formations. The Mahoosuc window contains three small, synclinal, inferred outliers of the Madrid and Littleton Formations. The Littleton Formation of this area is composed mainly of massive gray schist (within the outliers) or migmatitic gneiss (around the window) and is comparable to the Carrabassett Formation of Maine. The southwestern inferred outlier is enclosed in sharply interbedded quartzite and schist of the Perry Mountain Formation, but the two northeastern outliers truncate the Rangeley-Perry Mountain Formation contact. This relationship indicates that the Plumbago Mountain fault truncates earlier folds.

The inferred younger-over-older relationship and the apparent truncation of the Plumbago Mountain fault by the Mahoosuc fault are shown on section A-A' (Fig. 4). An alternative older-younger interpretation, turning the structure "inside out," would change the inferred window to an outlier, and the synclinal outliers to windows. Although the alternative is not ruled out, it seems easier to explain the synclinal bodies as outliers within a window rather than as synclines accidentally exposed as windows within an outlier.

**BLUEBERRY MOUNTAIN AND WINTER BROOK EARLY FAULTS AND THE RUMFORD ALLOCHTHON**

The Blueberry Mountain and Winter Brook faults are inferred to mark the sole of the Rumford allochthon, on the northwest and southeast sides respectively (Fig. 1a,b). The allochthon is cut internally by the Bald Mountain fault, which has not been seen in outcrop and is inferred to exist as a resolution of structural problems within the Devonian rocks of the allochthon.

The Blueberry Mountain fault extends at least from the Lexington batholith to the Songo pluton (Osberg et al., 1985). It is cut by several Devonian plutons. The small body of metamorphosed gabbro on the west side of the Rumford pluton (Fig. 1a,b) may be a remnant of a mafic body that was emplaced along the fault. The latitude is now covered by the Seboomook Formation, in contact with the Madrid Formation, displacement across the fault is small and the allochthon may not be completely detached nearby.

Southwestward, the Blueberry Mountain fault parallels the southeast limb of the Salem anticline; hence, just south of the Rangeley quadrangle, it slices across the core of the anticline to its west limb. This relationship is shown in detail in Figure 5. The oldest exposed formation in the core of the Salem anticline is the Rangeley Formation, which is truncated on the north side of the Blueberry Mountain fault. South of the fault is the Tory Hill syncline, which is mappable northeastward almost to the Lexington batholith. This early fold area also is truncated by the fault (Fig. 5). As shown, the fault and the earlier folds are strongly warped by the Tumbledown antiform and related late folds.

In the southwest corner of the area of Figure 5 are two, narrow, bent, canoe-like outliers of Seboomook Formation that are surrounded by the Perry Mountain Formation. A similar outlier is exposed about 6 km farther south-southwest (Moench and Hildreth, 1976). The Seboomook-Perry Mountain Formation contact is the Blueberry Mountain fault. Because these outliers are exposed on high ridges and are apparently synclinal, and because they lie to the northwest of the main trace of the Blueberry Mountain fault, they support the inferred younger-over-older structure of the fault, and suggest further that the fault originally dipped southeast.

Along the southwestern half of the trace of the Blueberry Mountain fault, the Carrabassett, Hildreths, and Seboomook Formations on the east are juxtaposed against generally west-younging rocks of the Rangeley, Perry Mountain, Smalls Falls, Madrid, and Carrabassett Formations, as shown in the lower cross section of Figure 6. The upper section is based on outcrops along and near Philbrick Brook, where the fault is exposed (Moench, 1970, Figs. 12, 13); the brook and location of the outcrop are shown by Moench and Hildreth (1976). The rocks are in the siltunitate zone of metamorphism; east of the Bunk Pond pluton the rocks are gneissic and migmatitic, but west of the pluton the rocks are well-bedded schist. Well bedded pelitic schist of the Seboomook Formation, shown above ground in the section, occupies the southernmost of the three small outliers described above; this outlier is about 2 km northwest of where it is shown in the section. Its position east of the main trace of the Blueberry Mountain fault suggests that the fault originally dipped southeastward. West of the fault is a generally west-younging sequence that includes, in ascending order, the Rangeley (exposed about 1 km south of the line of section), Perry Mountain, Smalls Falls, Madrid, and Carrabassett Formations. Where the Hildreths and almost-basal Perry Mountain Formations are juxtaposed, the stratigraphic separation is about 3 km.

The Tumbledown antiform is a post-cleavage, doubly plunging dome. We propose that it is a modified early anticline. If so, the west-younging sequence that lies between the crest of the antiform and the Blueberry Mountain fault might express back-tilting on the west limb of a rollover, now the tumbledown antiform, above an east-dipping, listric, normal fault, now the deformed Blueberry Mountain fault.

In addition to the outcrop of the Blueberry Mountain fault already described (Moench, 1970), the fault is exposed on the south limb of the southern outlier. The fault is 1.1 km north of the north knoll of Flathead Mountain in the Rumford quadrangle; its location is shown by Moench and Hildreth (1976). Here, well-bedded rocks of the Perry Mountain and Seboomook Formations are in knife-sharp contact; grade bedding on both sides youngs away from the contact. A peculiar feature (also seen on a branch of the Blueberry Mountain fault in the southeast corner of the Rangeley quadrangle) is a lens of quartzose metasandstone about 25 x 50 cm in cross section that occurs exactly on the contact. It is elongate parallel to bedding on both sides, which wraps around the lens. On the basis of its quartzose composition, the lens might have been derived from sandstone of the Perry Mountain Formation. Tentatively, this puzzling feature may be a result of disaggregation, redistribution, and subsequent "balling" of sandstone of the Perry Mount-
tain Formation under the conditions of high fluid pressure that probably existed along the fault.

The Winter Brook fault is part of the resolution of a controversy that "raged" between the two authors during mapping in the early 1970's. Whereas Moench believed that the predominantly gray pelitic rocks and arenites surrounding the Phillips pluton are Devonian in age and are overlain to the northeast (down-plunge and up-section) by younger arenites perhaps related to the Tarratine Formation of northern Maine, Pankiwskyj held that these northeastern arenites correlate with the Madrid Formation and are underlain to the southwest by facies of the Smalls Falls, Perry Mountain, and Rangeley Formations. While investigating the question, Pankiwskyj discovered and mapped the Winter Brook fault, as shown on Figure 1a. As a result, neither author was required to yield; and, moreover, they agreed that the Blueberry Mountain and Winter Brook faults probably are the same, forming the sole of a feature they called the Rumford allochthon. Pankiwskyj mapped
Some inferred elongate windows near the southeast side of the allochthon. These windows, according to our interpretation, indicate that the fault originally dipped gently to the northwest.

The Winter Brook fault takes its name from Winter Brook in the southwest corner of the Kingfield quadrangle, where the fault can be seen in outcrop (Pankiwskyj, 1979, p. 42). Here, black sulfidic schist and arenite of the Temple Stream Member of the Seboomook Formation and limy arenite of the Madrid Formation meet at a contact that cuts bedding in both formations; there are no intervening quartz veins. At two other localities, a quartz vein 1 cm thick occupies the trace of the fault; on both sides are zones in which rafts of metasandstone are enclosed in a matrix of less competent pelitic schist. These zones are interpreted as evidence of soft-sediment deformation (Pankiwskyj, 1979, p. 42).

Our interpretation of the Winter Brook fault differs from that of Osberg et al. (1985), who depict the fault as a low-angle, west-directed, older-over-younger thrust that extends at least 200 km across central Maine. Our windows become their outliers. Northeast of the Lexington batholith, the inferred thrust of Osberg et al. (1985) is a rather simple curvilinear feature that displaces the Carrabassett Formation northwestward over somewhat younger rocks of the Carrabassett or the Seboomook Formation, or the Madrid Formation over the Carrabassett Formation. For the most part, formations are not displaced out of their normal stratigraphic order, although at one place member C of the Rangeley Formation is in contact with the Carrabassett Formation. Osberg et al. (1985, section E-E') project the fault to a depth of 7 km nearly 40 km southeast of its surface trace. Reinterpretation as a high-angle thrust, or even a normal fault, would result in much simpler structure and a displacement of 1 km or less.

Southwest of the Lexington batholith, Osberg et al. (1985) depict the same feature, the Winter Brook fault of this paper, as a complexly deformed thrust having a far greater stratigraphic separation than its correlative northeast of the batholith. Southwest of the batholith, the Silurian Sangerville, Smalls Falls, and Madrid Formations are shown by Osberg et al. (1985) to lie discordantly above various members of the Seboomook Formation. The structure depicted on their section F-F' requires at least 20 km of thrust displacement. If outcrop characteristics can be disregarded, their interpretation is permitted by the fact there is no certain way in this area to determine younger-over-older versus older-over-younger relationships. The structure can be turned permissively "inside out" simply by placing the barbs (or teeth) on the other side of the fault.

We disagree with the thrust interpretation of the Winter Brook fault for two main reasons. First, it is a complex map pattern, and outcrop characteristics indicate that the Winter Brook fault belongs to the family of early faults mapped farther northwest. Second, present knowledge of Silurian lithofacies on both sides of the fault argues against the long-distance transport that is required by the thrust model. Moench and Pankiwskyj (1987) have divided the Madrid and Smalls Falls Formations into a western facies containing thinly-bedded calc-silicate rocks (upper part of Smalls Falls and lower part of Madrid Formations) and an eastern facies lacking these rocks. This facies change can be placed outside the allochthon of our interpretation a short distance south of the Lexington batholith (Fig. 1b), and within the allochthon about 8 km southeast of Rumford. It probably lies outside the allochthon a few kilometers northwest of the Songo pluton, but more data are needed in that area. Although the facies change is poorly controlled, as presently defined it is consistent with transport of only a few or several kilometers, but not, say, 50 km.

According to our interpretation, the Rumford allochthon originated as a body of semi-lithified, water-bearing sedimentary material a few kilometers thick that moved by gravity sliding a few or several kilometers to its present position. Folding accompanied movement and the body moved far enough over previously folded beds to produce the observed juxtapositions. The northeastern end of the body may not have been completely detached. Although we have no conclusive evidence that bears on direction of transport, we prefer a model of "crowding" toward an axial structural depression along the Kearsarge-central Maine synclinorium.

**SUMMARY AND CONCLUSIONS**

Northeast-trending premetamorphic early faults of western Maine and adjacent New Hampshire originated prior to Acadian compression, as steeply dipping, southeast-down normal faults along presently exposed relatively little-deformed straight segments, and as gently dipping, younger-over-older detachments along the complexly folded sinuous parts. All were probably listric.
The Hill 2808 and Mahoosuc faults, respectively northeast and southwest of the Mooselookmeguntic batholith, mark the boundary between pre-Silurian and Siluro-Devonian rocks along the Kearsarge-central Maine synclinorium and are tentatively correlated across the batholith. When considered as one feature, the fault extends at least 100 km from near Rangeley, Maine, to north-central New Hampshire. It is interpreted to be a deeply penetrating, southeast-down normal fault which, on the basis of its position near or on the Silurian tectonic hinge, marks the northwestern boundary of the ancestral basin of the synclinorium. The Hill 2808 segment, on the basis of its smaller displacement (0-3 km) and exposed features indicating that the wall rocks were poorly lithified during faulting, is inferred to represent shallower conditions than the Mahoosuc segment, which displaced Silurian and Lower Devonian strata several kilometers downward against hard Ordovician granite and older rocks. The fault cuts the limbs of early folds. However, on the basis of the relationship between the direction of increasing displacement along the Hill 2808 fault and the directions of plunge within the Mountain Pond syncline and Brimstone Mountain anticline to the southeast, early faulting and folding are shown to be coeval and dynamically related. The Hill 2808 fault may have begun to form as a growth fault during deposition of member A of the Lower Silurian Rangeley Formation. By analogy with Gulf Coast structure (see Moench, 1970), the Brimstone Mountain anticline is interpreted to have originated as an open rollover above the assumed listric Hill 2808 fault; the Mountain Pond syncline, lying between the anticline and the fault, may have formed by a combination of back-tilting and drag. During Acadian compression, these folds were greatly tightened and amplified, and slaty cleavage was overprinted across the whole fault-fold structure.

The Barnjum fault was originally mapped between its southwest end near Madrid, Maine, about 25 km northeast to the south end of the gabbroic Sugarloaf pluton, where the Lower Devonian Carrabassett Formation is down-faulted on the southeast against the Silurian Perry Mountain Formation. Between these two points, displacement increases northeastward to more than 1 km; a major syncline on the hanging-wall side plunges in the same direction. This relationship, similar to relationships already described between the Hill 2808 fault and adjacent folds, indicates a temporal and dynamic relation between early faulting and folding; and it shows that the sense of movement in the hanging wall of the Barnjum fault was scissor-like, and southeast and down.

We propose that the Barnjum fault once extended as a low-angle dislocation through a wide area to the north of its originally mapped segment. According to our interpretation, it passed northward from a rupture contained within the conformable Silurian-Devonian basin sequence to one that dislodged shoreward facies of these deposits, approximately along their basal unconformities. The fault is inferred tentatively to mark the sole of the Kennebago outlier, which centers 25 km northwest of the originally mapped segment, but this interpretation is not essential to our hypothesis. We favor a southeastward direction of transport for the whole feature on the basis of the fault-fold relationships already described along the segment of the Barnjum fault that lies between Madrid and the south end of the Sugarloaf pluton. The fault may have originated as a growth fault during deposition of the Silurian Smalls Falls Formation, but the latest movements occurred after deposition of the Lower Devonian Seboomook Formation. Interpreted as a wide-spread, southeast-transported, low-angle detachment feature that steepens southeastward across the Silurian tectonic hinge and eventually dies out and becomes attached within the basin sequence, movement along the Barnjum fault may be likened to a rug sliding down an incline, but tacked to the bottom and one side of the incline. Emplacement of gabbroic magma along the dislocation may have triggered movement.

The Plumbago Mountain early fault is contained within the synclinorium sequence and has a known strike-length of about 70 km, extending from its northeast end about 7 km southwest of Madrid, Maine, almost to Gorham, New Hampshire. It cuts the limbs of earlier folds and is truncated by the Mooselookmeguntic batholith and other plutons. For a distance of about 15 km northeast of the batholith, the fault has a straight trace, indicating a probably steep original dip. The maximum offset here is somewhat less than 1 km, southeast side down. Farther southwest, the trace of the fault becomes increasingly complex, owing to younger folding, and larger amounts of section are excised. Gentler dips and larger displacements are indicated. Structural relationships suggest, but do not prove, that younger rocks lie structurally above older rocks. The most compelling evidence that supports this interpretation is seen in the inferred Mahoosuc window, exposed along the Mahoosuc Range in New Hampshire, where three synclinal bodies of younger rocks occur that would be difficult to explain by an alternative older-over-younger interpretation.

Farther southeast are the Blueberry Mountain and Winter Brook early faults, which outline the 30 × 75 km Rumford allochthon, which lies along the axial zone of the Kearsarge-central Maine synclinorium. The allochthon is interpreted as a body of mainly Lower Devonian rocks that lies discordantly above autochthonous Silurian rocks. We infer that the Blueberry Mountain and Winter Brook faults, respectively, mark the northwest and southeast sides of the allochthon and join at depth to form the sole of the allochthon. The allochthon is ruptured internally by the Bald Mountain early fault. On the basis of the distribution of inferred windows and outliers near the margins of the allochthon, we believe that the allochthon is a younger-over-older detachment whose sole dips inwardly. It does not appear to be far-travelled, and we propose that it formed by detachment and crowding near the axis of the ancestral basin.

Probably the most difficult remaining problem is the younger-over-older versus older-over-younger controversy, which applies specifically to the Plumbago Mountain fault (and Mahoosuc window) and the Blueberry Mountain and Winter Brook faults (and Rumford allochthon). Without disrupting map patterns, the inferred windows and outliers of our interpretation can be turned "inside out," to form older-over-younger thrusts. The small syn-
clinal inferred outliers that occur within the inferred Mahoosuc window and on ridges northwest of the main trace of the Blueberry Mountain fault support our interpretation, but not conclusively. By turning windows into outliers and outliers into windows along the Winter Brook fault, but not along the Blueberry Mountain fault, Osberg et al. (1985, sections E-E', F-F') interpret the Blueberry Mountain fault as a low-angle normal fault and the Winter Brook fault as a low-angle thrust fault of large displacement. On the basis of their conspicuous similarity, however, we consider the Plumbago Mountain, Blueberry Mountain, and Winter Brook faults to belong to the same family of structures; as such, a common origin seems necessary.

The most compelling line of evidence for the younger-overolder model is the comparison of coeval sedimentary facies across major faults. Whereas the younger-overolder model requires only horizontal displacement (a few or several kilometers) to account for the structural juxtapositions, the older-over-younger thrust model requires long-distance transport across strike, say from the margin to the center of the sedimentary basin. Under the thrust model one would expect to see a juxtaposition of sedimentary facies derived from different parts of the basin. So far, no such juxtaposition has been identified.

Another problem is presented by the observations: (1) that the early faults truncate the limbs, and locally the axial traces of folds; (2) that folding and faulting are demonstrably contemporaneous near the ends of two early faults; and (3) that the faults are deformed by early cleavage and folds that predate emplacement of the 400 Ma Lexington batholith, and are further deformed by younger folds. The apparent inconsistencies between relationships (1) and (2) can be resolved by a model of simultaneous faulting accompanied by folding along two or more sub-parallel listric faults. According to this model, a syncline-anticline pair that developed contemporaneously with faulting within the rocks above one fault would tend to be “decapitated” by the next higher, or basinward, fault. Carried to the extreme, the resulting pattern of juxtapositions would be very complex. Almost everywhere the faults would cross the limbs of contemporaneous folds; but only near the identified ends of faults would evidence be preserved that faulting and folding were in fact contemporaneous. During younger compression (3), anticlines and synclines that developed earlier would only be tightened and amplified, as we infer to have happened in the area of this study.

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