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Title: *Tectonic Fabrics of the Passadumkeag River Pluton, Bottle Lake Complex, Springfield and Scraggly Lake 15-minute Quadrangles*

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Tectonic Fabrics of the Passadumkeag River Pluton, Bottle Lake Complex, Springfield and Scraggly Lake 15-minute Quadrangles

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INTRODUCTION

This report presents the preliminary results of a four-week field study of the Passadumkeag River pluton and contact aureole in the Springfield and Scraggly Lake 15-minute quadrangles, and analysis of samples collected during that study. The primary object of the study was the definition of brittle and ductile shear fabrics in the Passadumkeag River granite, and the relation of these fabrics to major fault systems found to the north of the study area, particularly those described by Ludman (1985), Morisi and Ludman (1985), and myself. Of necessity, this was a reconnaissance study, with detailed reconnaissance of some key areas; the results of the study, however, are extremely significant for the understanding of Late Acadian tectonics in this part of the state.

Four distinct trends of fractures and shears have been defined, trending approximately N5°W, N40°W, N45°E, and S75°E; the latter two bear the most significance for the regional tectonic picture. The N45°E fabric, in particular, is directly related to dextral oblique faults which were active throughout and following the emplacement and cooling of the pluton. Response of the granite to shear on all these trends varied as cooling proceeded, so that relatively precise timing of the faulting associated with Late Acadian deformation has been obtained. Relation of these fabrics to structures in the surrounding sedimentary and volcanic rocks of the Kearsarge-central Maine, Aroostook-Matapedia, and Miramichi tracts produces a more complete picture of Late Acadian tectonics in eastern Maine than any obtained thus far. This picture remains incomplete in many key areas, requiring further study, and much of the Early Acadian, and pre-Acadian history remains uncertain as well.

GENERAL ASPECTS OF TECTONIC FABRIC

The primary sources of information on tectonic fabrics of the Passadumkeag River pluton, prior to the present study, have been the report of Ayuso (1984), and a series of lineament maps prepared for the Maine Geological Survey, covering portions of the Millinocket and Fredericton 2-degree sheets. Ayuso's work is primarily geochemical, and he was careful to describe his structural work as "preliminary" (Ayuso, 1984, p. 43); he nonetheless notes the appearance of several structural elements related to those detailed in this study. Most significantly, he describes northeast-trending mylonitic zones within the adjacent Whitney Cove pluton, which are shown on this map (Ayuso, 1984, Plate 1) to lie at a low angle to the more east-trending Norumbega fault zone. One such zone is shown terminating against the Passadumkeag River pluton, implying that it is unaffected by this faulting and therefore younger than the Whitney Cove pluton. Also described from the Whitney Cove pluton, but not in the Passadumkeag River, are east-west trending mylonite zones which Ayuso does not relate to any regional structures. Further evidence for the relative ages of the plutons, given by Ayuso, is that "....rock types characteristic of the Passadumkeag River pluton intrude rocks typical of the Whitney Cove pluton" (Ayuso, 1984, p. 6). Radiometric ages cited by Ayuso (op. cit., p. 5-6) for both plutons generally overlap, ranging from 374 to 404 Ma. For the purposes of this report, and the timetable of Late Acadian events developed below, it seems safe to consider 385 Ma as the pluton age; certainly it would be no older than 400 Ma, and no younger than 375 Ma.

The lineament maps are of two types, one set produced from air photos, the other from Landsat imagery; rose diagrams summarizing each map are given as Figure 1, a-d. The dominant trends shown by both types of map are approximately due north, N40°E, and N40°W; the N60°E trend in the Fredericton maps reflects the overlap of the Norumbega fault zone with the map area. East-west structural trends are absent from these maps, although Ayuso, as noted above, described some structures with this orientation from the field.

Figure 2 is a rose diagram showing the pattern of all brittle fractures, predominantly joints, mapped during field work for

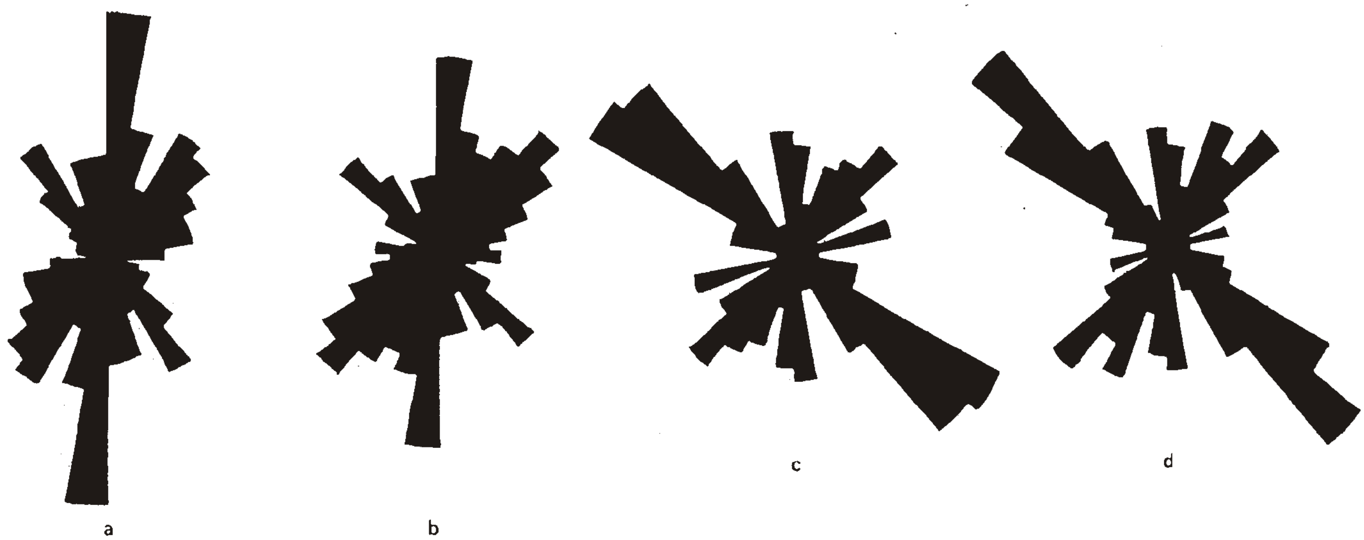

Figure 1. Rose diagram structural fabrics indicated on lineament maps drawn from Landsat photographs and air photos of selected ares in the Fredericton and Millinocket 2-degree sheets: a) Millinocket Landsat, n=113; b) Fredericton Landsat, n=62 c) Mmillinocket airphoto, n=225; d) Fredericton airphoto, n=135. Tick marks denot 10%.

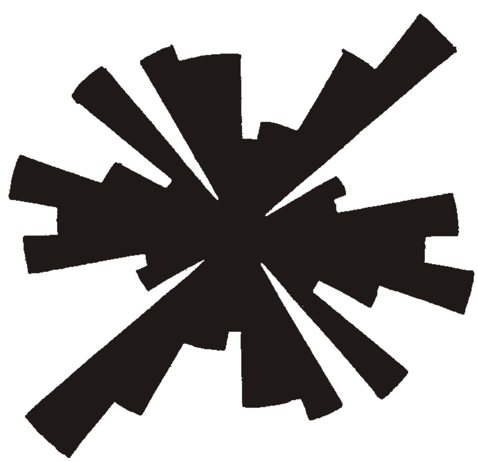

Figure 2. Rose diagram showing orientation of all brittle fractures measured in the field during this study. Tick marks denote 10%; n-157.

this present study. This figure reveals fabric elements trending approximately N5°W, N45°E, N40°W, and a strong N75°W fabric absent from the lineament maps. The N40°W trend is not as striking as it appears on the lineament maps, most likely because the regional trend of glacial lineations is also approximately N40°W. Glacial and bedrock fabrics cannot be distinguished on the lineament maps, and the tectonic significance of the N40°W trend is exaggerated on rose diagrams drawn from them.

The appearance of each of these trends in the field and in thin section is generally distinctive. The N40°W trend appears as a straightforward, regionally penetrative jointing fabric, producing widely spaced, near vertical, rough-surfaced fractures in outcrop. Dikes parallel to this trend are rare. This fabric is the only one of the four that does not manifest itself in thin section; the other three all appear as thin linear zones of high strain and occasional cataclasis.

The N5°W trend is defined in outcrop by near-vertical joints with generally planar faces; spacing on these fractures is quite variable, ranging from a few inches to several tens of feet, although a wider spacing of several feet is more common. It is also associated with pegmatitic dikes along the pluton margin, and other, minor dikes in the pluton core; the dikes are described in further detail below. This fabric is frequently absent from thin section, but it is found in thin sections of the pegmatites, as an extremely narrow zone of highly strained and frequently fractured grains, with no apparent offset. Biotite (?) grains are common along these zones and are typically highly deformed.

Fabrics trending approximately N75°W are ubiquitous in the study area. They most commonly take the form of narrow zones of anastomosing fractures, ranging in width from almost two inches down to a single fracture along any one trend, although a width of one-half to one-quarter inch is most common. Spacing of these zones varies from four inches to several feet. Joints parallel to these fractures tend to have relatively smooth, planar faces; no slickensides were observed along these faces, and no unambiguous offset is apparent on these fractures in the field. Dikes parallel to this trend are relatively uncommon. In thin section this fabric is nearly always present, taking the form of a zone of highly strained and commonly fractured grains up to 1 mm in width. Cataclasis is common but not typical, and single fractures are rare, unlike the due-north fabric, or the N45°E fabric discussed below, which tend to appear in thin section as thin zones of high strain, less than 0.2 mm in width, typically with narrower zones of cataclasis or single brittle fractures. Minor offsets, less than 0.2 mm, are rare; where present, they tend to be sinistral in the plane of horizontal sections. Usually no offset is apparent across these zones.

The N45°E fabric is the most diverse of the four in terms of the forms it takes in the field, and, in terms of understanding the regional tectonics, it is perhaps the most significant. It is most common as near-vertical joints with relatively smooth, planar faces, but is also represented by dikes, zones of brittle and ductile shear, and extensive hydrothermal alteration, typically selective kaolinitization of plagioclase and deposition of hematite in closely spaced vertical fractures; hematite composes 10-15% of some samples by volume. These latter three tend to occur in association, although not all dikes show macroscopic evidence of strain. Spacing of the joint fabric, and its dominance on individual outcrops, appears to be related to proximity of the outcrop to one of the zones of faulting and hydrothermal alteration. This suggests that the effects of strain along particular faults is distributed through a much wider band of granite than that immediately adjacent to the fault itself, although this is difficult to prove, given the general poverty of exposure. For this same reason, it is difficult to gauge the exact width of particular fault zones, although the Rand Hill exposures, discussed below, suggest that the zone of intrusion, alteration, and cataclasis may be on the order of one hundred feet in width. Dikes associated with this trend tend to be pink granites, possibly bearing iron-rich feldspars reflecting the same Fe-enrichment of late-stage magmas shown by the hematite. Most dikes in the Passadumkeag River pluton, whatever their orientations, are thumb-width or thinner, but some zones of pink granite in the southeast portion of Lakeville Township are at least one hundred feet in width. Macroscopic cataclasis of these granites is not apparent, but they do bear prominent, closely spaced, N45°E-trending joints, and zones of high strain and cataclasis trending approximately N45°E are seen in thin sections of these granites.

Thin section textures associated with the N45°E trend are similar to those described above, although they occur in a greater variety of lithologies. The highly strained zones, in this case, are more often clearly associated with offsets of fractured grains and extensive cataclasis of the strained mineral grains. Many of the dike rocks, even those not found in association with the hematite-bearing zones, show extensive alteration of feldspars and amphiboles; feldspars, preferentially plagioclase, generally are altered to sericite along twin and compositional zone boundaries, and amphiboles to chlorite. Hydrothermal minerals, commonly epidotes and possibly some zeolites as well, are often fractured as well, but do not show the extensive alteration seen in plagioclase. Thin, anastomosing bands of dark, amorphous material, resembling pressure solution folia, occur in many of the wider cataclasite zones, trending N45°E.

Ayuso (1984) described the occurrence of relatively rare dikes in the pluton, but did not distinguish systematic orientations of these dikes. Figure 3 shows that, in general, dike orientations parallel the structural trends defined in Figure 2, with the lion's share subparallel to the N5°W trend, a lesser share along the N45°E trend, and only minor diking parallel to the remaining two trends.

Dikes observed in the Passadumkeag River pluton may, if crudely, be sorted into four types: thin felsic granites, zoned pegmatites, pink granites, often bearing epidote veins, and hydrothermally altered zones. The first type, simple thin felsic dikes, rarely greater than an inch in width, are the most common. These dikes occur along all the structural trends, but the N40°W and N75°W trends bear only dikes of this sort.

Zoned pegmatite dikes, with coarse, feldspar-rich, leucocratic margins and cores consisting almost entirely of medium-grained quartz, with minor amounts of feldspar and biotite, are found only along the N5°W trend. The quartz-rich zone is not always present; where it is found, it may be up to one-and-a-half inches in width, with margins up to half an inch thick on either side. Contacts between the leucocratic margins and the host granites are sometimes gradational over a quarter inch or so, possibly reflecting alteration of the host rock. These dikes are found in place at only one locality, at the very margin of the pluton on Granite Ridge in the Springfield quadrangle, but

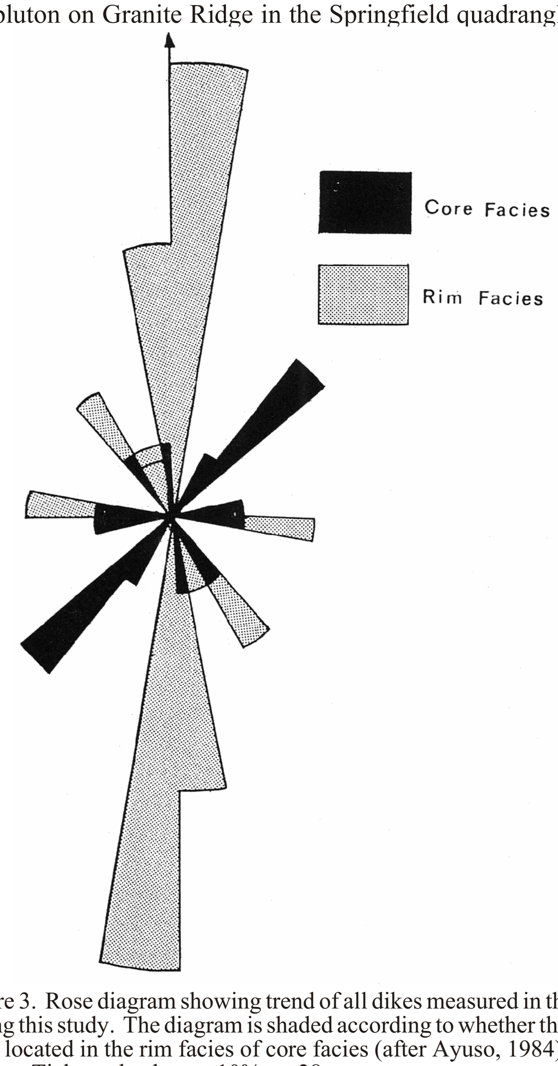

Figure 3. Rose diagram showing trend of all dikes measured in the field during this study. The diagram is shaded according to whether the dikes were located in the rim facies of core facies (after Ayuso, 1984) of the pluton. Tick marks denote 10%, n=28.

have been seen in float in the southeast quarter of Lakeville township. The dikes are interpreted as forming along cooling cracks developed perpendicular to the pluton margin; the east-west trend of that margin throughout the study area may well have led to exaggeration of the N5°W trend in Figure 3. Figure 3 divides the dikes into two populations, those found within Ayuso's rim facies granite, and those within his core facies. These pegmatites dominate the rim facies trend and are absent from the core.

The two remaining dike forms are exclusive to the N45°E trend, and, as far as this preliminary survey has found, to the core of the pluton as well. (As these dikes occur along regional faulting trends, I expect that similar igneous bodies will eventually be located in the pluton rim, unless the rim was too far removed from the remaining magma at the time of faulting.) Pink granite dikes range in width from less than an inch to possibly over a hundred feet. These dikes often contain thin veins, sometimes with comb structure, of euhedral and subhedral epidote, and typically show thin zones of highly strained and fractured grains parallel to the N45°E trend. These zones may be apparent on a macroscopic scale as cataclasite bands several millimeters in width, as on Rand Hill (see below), or only found in thin section. Sericitization of some feldspars along twin planes and compositional zone boundaries is common in these rocks.

The hydrothermal zones are characterized by alteration of plagioclase to kaolinite and sericite, and deposition of hematite along thin, closely spaced, vertical fractures. These zones are perhaps several tens of feet in width. Only on Rand Hill is one exposed in cross-section; it is some thirty-five feet in width, with margins gradational over eight-to-ten feet. Altered zones do not occur as marginal facies of the pink granites, although they are often found in association, but are interpreted as a distinct, later event related to escape of Fe-bearing magmatic waters along the same active faults on which the pink granites were intruded earlier. Extensive cataclasis of these altered rocks shows that activity on these faults continued after cooling of the pluton.

KEY LOCALITIES

This section provides thumbnail descriptions of certain localities considered crucial to the development of the tectonic history presented in this report. Many of the particulars of these localities have been discussed already; the purpose of this section is to place those features in their local context, to emphasize the importance of a few key exposures in an area poor in outcrop, and to suggest that efforts should be made to preserve at least one of these exposures — that on Rand Hill — for further study.

Rand Hill

Numerous good exposures of the core facies of the Passadumkeag River pluton occur on Rand Hill in the Springfield quadrangle, primarily along an unpaved road leading from south of Weir Pond, along the south shore of Upper Sysladobsis Lake, and joining with the road leading south from Springfield to The Pines. The most significant exposure lies southeast of the crest of the hill, just north of the 480-foot surveyed point shown on the Springfield 15-minute map. The outcrop stretches perhaps two hundred feet, in a pit dug into the east side of the hill, lying to the west of the road itself. Much of the exposure is deeply weathered, but relatively fresh surfaces can be easily obtained with a little scraping, and good float blocks are plentiful. Three lithologies are exposed; the first is apparently a deeply weathered granite of Ayuso's core facies, and need not concern us further. The other two are a pink-to-red granite with abundant, closely spaced vertical fractures, and a metasomatically altered, red mottled granite bearing abundant hematite, also in closely spaced vertical fractures.

The pink granite occurs as a five-foot-wide dike, trending approximately N45°E, nearly vertical, broken by numerous fractures spaced less than half an inch apart. In thin section, these fractures are seen to be filled with material, interpreted as a cataclasite, consisting of amorphous, sericitized(?) material, fragments of quartz and feldspar grains, and epidote, occurring both as fragments and as euhedral crystals along fracture walls. Not all of the fragments are compositionally related to adjacent grains, suggesting some mobility of the cataclasite fracture fill during faulting. Alteration textures are prominent throughout, principally sericitization of feldspar along twin and compositional zoning boundaries, and alteration of biotite and amphibole to chlorite. Both quartz and feldspar grains are typically highly strained and fractured throughout the rock. Within the cataclasite are dark, thin, anastomosing zones resembling pressure solution folia; several grains are abruptly truncated against these, possibly indicating late strain along this same trend.

The metasomatically altered granite shows selective kaolinitization of plagioclase, and is penetratively fractured, with numerous closely spaced, hematite-filled vertical fractures. Irregular zones of cataclasite, up to one inch in width, are found throughout this lithology. This zone is perhaps fifty feet in width, with margins gradational over eight-to-ten feet.

This outcrop is interpreted as an exposure of a fault zone which was active during and after the latest stages of intrusion and cooling of the Passadumkeag River pluton. This fault is not exposed elsewhere in the pluton, although other exposures of similar lithologies are not uncommon. Similar altered granites are found in outcrop along the south side of Upper Sysladobsis Lake, and in the southeast corner of Lakeville township. A search for the northward continuation of the Rand Hill fault will be part of the 1988 field program.

Granite Ridge

Granite Ridge, in the southernmost part of Springfield township, bears several excellent pavement exposures that lie along the contact between the Passadumkeag River pluton and the surrounding metasediment. Granites here belong to Ayuso's rim facies; the metasediments are biotite-grade sandy metapelites, many of which retain bedding and sedimentary structures. Thin veins of calc-silicate minerals are common here, and more common around Tredwell Hill, immediately to the west, where crosscutting calc-silicate veins may indicate multiple thermal events. Foliation in the metasediment on Granite Ridge is often warped around lenses and pods of granite, most likely indicating plastic deformation of hot country rock adjacent to the intruding granite. Thin, discontinuous stringers of very-fine-grained granite within the metasediment may represent minimum melt of the country rock. In thin section, the folding of the foliation and distortion of the granite veins are not accompanied by any straining of grains in either igneous or metamorphic rocks, supporting the idea that this distortion is synchronous with intrusion.

Jointing in the granite at these exposures belongs to the N5°W and N75°W sets. N5°W joints are paralleled by the zoned pegmatite dikes described above, and their traces are generally marked by rusty stains along the fracture. This close to the contact, these dikes may well have developed along cooling fractures formed perpendicular to the pluton margin. One dike veers from the due-north orientation, swinging to approximately N45°E for ten inches, and then rejoining the more northerly trend. As there is no macroscopic evidence of brittle fracture related to this apparent folding, it must have developed while the margin was relatively plastic. Whether it represents simply one dike jumping to an adjacent fracture in a relatively cool margin, or actual dextral shear folding of a dike in a crystal mush, remains uncertain; the former is considered more likely, since no other dikes show folding at this locality.

In thin section, the quartz of these dikes shows brittle fractures trending parallel to the dike margins, as well as the ubiquitous N75°W fabric. It is not clear at present if this north-trending deformation records activity on an inferred north-trending splay of the North Bancroft fault paralleling Mattagodus Stream, or whether shear along the N45°E trend has here accommodated itself to a strong compositional boundary. Foliation in the metasediment here trends approximately N40°E.

Other Localities

Grouped under this heading are brief discussions of two areas, the complexities of which are beyond the presently available data, but which do provide evidence for the sequence and timing of deformation, particularly post-metamorphic deformation.

The numerous outcrops on reconstructed lumber roads around Cushman Ridge, southwest of the town of Springfield, show highly deformed limestones of the Carys Mills Formation cooked to just within the biotite isograd. The prominent foliation in these rocks trends N50°E, but it is tightly folded about a parallel trend; the sequence of events indicated by this folding is the same as that discussed below, determined along the North Bancroft fault in the Wytopitlock quadrangle. Exact location of the fault mapped on Cushman Ridge is speculative, and based on an apparent increase in intensity of deformation northward across the ridge. Alternately, this could reflect local variations within a wide zone of deformation usually found within the Carys Mills Formation along its contact with the Siluro - Devonian sandstone and pelite section. Thin sections of the Cushman Ridge limestone show foliation defined by fine euhedral grains of biotite; small kinks are common, however, tightly folding these grains about a N30°E trend.

An extensive clearcut north of Lombard Lake covers an area underlain by calc-silicate rock and cordierite-bearing metapelite. Exposures in this area are not particularly good, but samples from the ones which do exist show unambiguous evidence of post-metamorphic deformation. Biotite grains and calcite crystals in the calc-silicate rocks are clearly deformed and truncated against thin, anastomosing folia resembling insoluble residues along solution cleavage. In the metapelite, irregular boundaries of retrograded cordierite porphyroblasts are similarly truncated against apparent solution folia. Rotation of the porphyroblasts is ambiguous, but the foliation is clearly distorted around them, and pressure shadows are found adjacent to many of them. Minimum-melt (?) granite veinlets of similar morphology to those found on Granite Ridge are also present in these metapelites; they show a similar pinch-and-swell structure, but here that structure is associated with some strain shadowing of grains in the granite and distortion of grains in the pelite. Pull-apart areas between granite lenses are filled by iron sulfides and micaceous material, generally poorly preserved. Open kinks of biotite grains in the foliation, trending approximately N70°W, are also found.

TIMING OF ACADIAN DEFORMATION IN EASTERN MAINE

This study of the Passadumkeag River pluton, together with previous research by myself and others in the Springfield, Wytopitlock, Danforth, and Scraggly Lake quadrangles, has led to the development of a relatively precise timetable of previously undated deformational events, due to the presence or absence of characteristic structures in the pluton, and the variable response of the granite at various stages of its cooling history. The general pattern of events is summarized in Figure 4 and discussed in detail here.

The characteristic Acadian deformation in eastern Maine is the development of open, upright folds with axial surfaces and axial planar S_1 cleavage trending N20 - 30°E is clearly present in the country rocks surrounding the Bottle Lake Complex. The subsequent D_2 deformation involved high-angle deformation on faults of the North Bancroft and Stetson Mountain systems. Potentially, these faults are surface traces of deep basement structures (Ludman, 1986) which break through the folded Siluro - Devonian sedimentary cover as reverse faults at the climax of Acadian crustal shortening. D_2 deformation is limited in areal extent to rocks very close to traces of these faults; on the east side of the Bancroft railroad bridge in the Wytopitlock quadrangle,

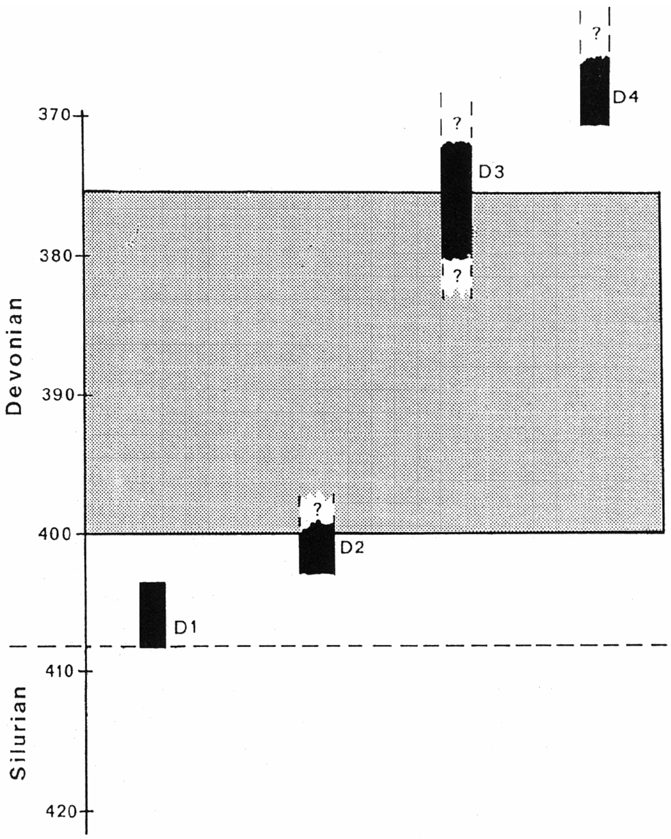

Figure 4: Diagram showing approximate time ranges for various stages of Acadian deformation affecting rocks of the Passadumkeag River pluton and surrounding country rocks. The horizontal dashed line marks the Silurian - Devonian boundary; vertical axis is scaled in millions of years. The shaded envelope represents the widest reasonable time envelope for intrusion of the Bottle Lake Complex. "Absolute ages" of the deformations are dependent, in part, on the time span of this envelope; the sequence of deformations with respect to one another and to pluton emplacement is certain.

conglomerates of the Daggett Ridge Formation are intensely sheared adjacent to the North Bancroft fault in the Mattawamkeag River, where fractured pebbles indicate a high-angle deformation. Less than a quarter mile away, however, the conglomerates remain massive. In part, this may reflect the competency of the unit; in the Cary's Mills Formation, on the west side of the North Bancroft fault, D_2 deformation seems more intense, with S_1 layering, axial planar to D_1 folds, tightly folded and sheared in a sense indicating west-side-up high-angle motion on the fault. An S_2 foliation consisting of a solution cleavage and high-angle shear planes is common at this locality, but seems rare in admittedly poorer exposures at greater distance from the fault.

D_3 is recognized in the low-grade rocks as a dextral oblique slip along the same faults active during D_2. It is apparent throughout the lower Paleozoic section as steeply plunging folds in bedding and S_1 layering, and also as en enchelon folds with axial surfaces trending approximately due north. The occurrence of these folds is inferred from a variably plunging crenulation in the plane of S_1, and from offsets in the outcrop pattern which do not appear to be related to faulting. Disharmonic dextral folding of the S_2 cleavage in both the Carys Mills and Daggett Ridge Formations shows that this event must postdate the D_2 high-angle faulting.

D_4 is a clearly distinct event, apparently unrelated to the dominant fault systems; it is defined by sinistral kink bands oriented E-W to N70°W. Most prominent in less competent units such as the Cary's Mills, this is sometimes seen as open warps of S_0 and S_1 in all other units. These kink bands are not offset along S_3 slip planes, and it is inferred that this event must be younger than the dextral D_3.

The major crustal shortening associated with D_1 must predate intrusion of the granite, so that D_1, in the Springfield area, is confidently dated as prior to 385 Ma. Rocks affected by D_1 in the Danforth quadrangle have produced Upper Silurian fossils (Ludman, 1985), so this event cannot be much older than the Siluro-Devonian boundary, as shown in Figure 4. S_1 foliation, which in the Wytopitlock and Danforth quadrangles trends generally N20-30°E, swings to N40-50°E somewhere immediately north of the biotite isograd in the Springfield quadrangle, as seen in Plate 1. It is confidently identified as S_1, however, on the basis of its orientation subparallel to bedding in the metasediment and the fact that it is the oldest tectonic fabric present in the rocks of the aureole. Why the orientation of the fabric and bedding should change as the pluton is approached is by no means clear. It may, in part, reflect the shouldering aside of country rock as the pluton expanded, but, as faults within both pluton and aureole also trend N40-50°E in this area, that cannot be the entire cause. The map (Plate 1) in this report reflects a model considered likely at present, in which a fault trending approximately N40°E, parallel to a lineament along Mattakeunk Stream, links the North Bancroft fault zone to another zone farther to the west, possibly the Kingman fault zone, defined by Morisi and Ludman (1985). Further mapping in the northwest quadrant of the Springfield quadrangle in the summer of 1988 will do much to resolve this problem. In any event, this foliation is clearly older than the Passadumkeag River pluton; in many places, particularly Granite Ridge in the Springfield quadrangle, it is seen to terminate abruptly against the granite.

If D_2, as presently defined, is primarily a compressive event, it seems unlikely that a significant volume of granite could have intruded during this phase, although there is no direct evidence that this is the case. In Figure 4, therefore, D_2 is assigned to, primarily, a pre-pluton age. It cannot be much later than D_1, and, as it may reflect the same regional stress field, the two may overlap slightly.

Evidence exists for a gap between the cessation of D_2 and the initiation of D_3, beyond the necessary change in the regional stress field. Thin sections of chlorite-grade rocks from the Wytopitlock and Danforth quadrangles showing both S_1 and S_3 reveal S_1 defined by thin folia of fine chlorite crystals, while S_3 is defined by thin, amorphous, sometimes weakly pleochroic folia of apparent solution residue, implying that the deepest burial of these rocks, and the regional phase of greatest metamorphism, lies between D_2 and D_3.

D_3 events included the faulting of the Passadumkeag River pluton as well as the nearby Center Pond pluton, and the development of the mylonite mapped by Ayuso within the Whitney Cove pluton. D_3 must begin after the intrusive phase of the Passadumkeag River pluton is almost complete, and continue well after the end of crystallization. The offset along any one fault during D_3 cannot have been great, however, as there are no apparent sharp changes in metamorphic gradients, and the pluton margin is not presently mapped as offset. The most obvious D_3 effects in the Passadumkeag River include the faults and dikes on Rand Hill, and other, similar, structures and lithologies elsewhere in the study area. The high strain and cataclasis associated with N45°E-trending fractures must also be a late D_3 event. The deformed pegmatites on Granite Ridge, discussed above, may have undergone brittle deformation during D_3 due to late motion on a splay of the North Bancroft fault trending down Mattagodus Stream in the Springfield quadrangle, as shown in Plate 1. The warping of these dikes may represent either late D_2 effects on the crystal mush of the pluton rim, or a jumping of the dike from one cooling crack to another. D_3 effects within the aureole are less pronounced, but nonetheless present. Kinking of biotite in samples from Cushman Ridge is assigned to D_3, as are the distortion of foliation around cordierite porphyroblasts, brittle fracture of minimum-melt dikes, and solution cleavage found in the metapelites north of Lombard Lake. D_3 cannot have begun before about 385 Ma, and must have continued after cooling, placing the minimum-age bracket no older than about 375 Ma. This dextral oblique faulting is distinct from the Norumbega event, but it is not impossible that it continued until that time.

D_4 is found in the granite as the ubiquitous N74°W fracturing, and the associated zones of high strain and cataclasis observed in thin section. East-west trending mylonite zones found by Ayuso in the Whitney Cove pluton (Ayuso, 1984, p. 43) may also be of D_4 age. All structural fabrics associated with D4 indicate that this event must be younger than the final cooling of the pluton, certainly younger than 385, and probably younger than 370 Ma. Evidence at present indicates that D_3 must have been complete prior to initiation of D_4.

This timetable obviously must be refined by further field study. Two areas are considered crucial for study during the 1988 field season: First, the northwest quadrant of the Springfield quadrangle must be explored to determine the nature and extent of the change in S_1 orientation from N20°E to N40°E, and whether this is indeed related to faults linking the North Bancroft zone with other faults to the west. Second, the area between Upper Sysladobsis Lake and the pluton margin must be thoroughly explored in order to link the Rand Hill fault with other faults within the aureole. The map shows a fault located by Ludman (1987, pers. comm.) near the pluton margin, which is hypothetically linked with the Stetson Mountain fault. This may link up with a fault south of Upper Sysladobsis Lake, inferred from outcrops of hydrothermally altered, hematite-bearing granite. I do not feel at present that the Rand Hill fault can be made to link up with the Stetson Mountain fault directly, and plan to explore the area north of Upper Sysladobsis Lake to find its continuation into the aureole.

CONCLUSIONS

1) Granite of the Passadumkeag River pluton is penetratively fractured, with orientations of the fracture sets trending approximately N5°W, N45°E, N40°W, and N75°W.

2) At least two of these fracture sets, N45°E and N75°W, are unambiguously related to zones of high strain and cataclasis within the granite and to tectonic structures in the surrounding lower Paleozoic sedimentary sequence.

3) All major crustal shortening, and, therefore, the present configuration of the Kearsarge - central Maine, Aroostook - Matapedia, and Miramichi tracts must have been attained well prior to 385 Ma.

4) Dextral oblique faulting beginning approximately 385 Ma has penetrated the Passadumkeag River pluton along several faults, although the total offset appears to have been minor. Some of this faulting may be as recent as Norumbega age, although these structures are distinct from those of the Norumbega fault zone.

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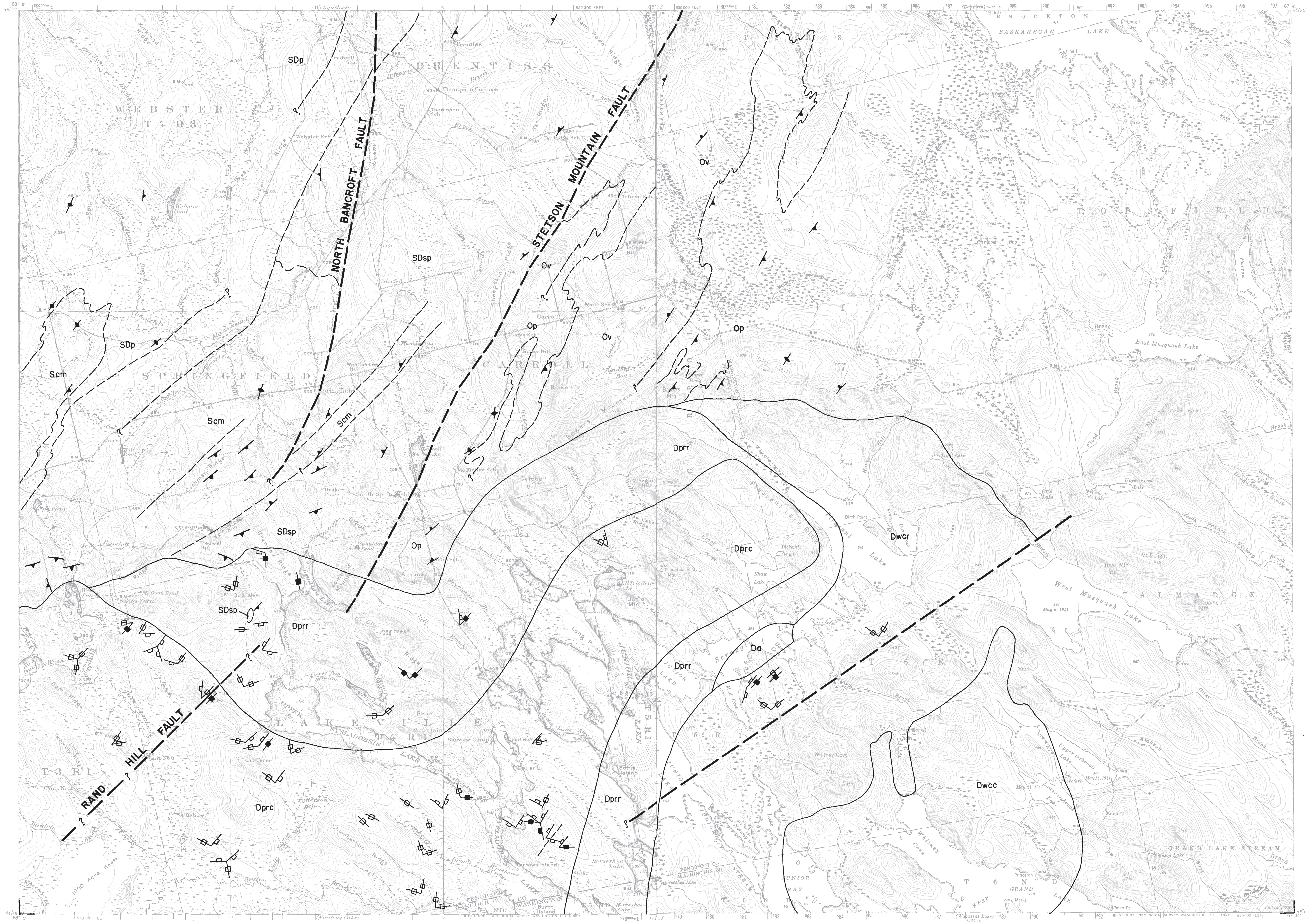

Plate 1

GEOLOGIC MAP OF PARTS OF THE

SPRINGFIELD AND SCRAGGLY LAKE 15-MINUTE QUADRANGLES, MAINE

by

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DEPARTMENT OF CONSERVATION
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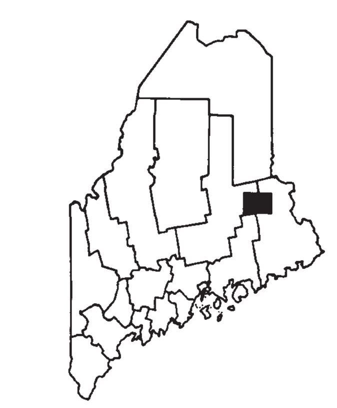
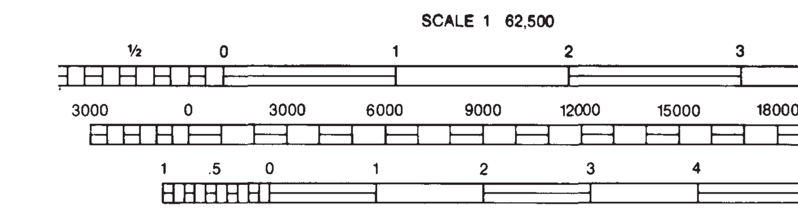


Quadrangle Location



Granite contacts are adapted from Ayuso (1984); many of the data in the sedimentary sequence are adapted from Ludman (1985, 1988, in prep).

VOLCANIC AND SEDIMENTARY ROCKS

- SDsp — Interbedded sandstone and pelite, carbonaceous places, often rhythmically bedded
- SDp — Pelitic unit with thin silty interbeds, tending to green and red in color toward top(?) of section (west), usually gray (Smyrna Mills Formation?)
- Scm — Thinly layered silty limestones: Carys Mills Formation
- Ov — Volcanic rocks of the Miramichi anticlinorium
- Op — Pelitic rocks of the Miramichi anticlinorium

INTRUSIVE ROCKS

- Dprr — Rim facies of the Passadumkeag River pluton
- Dprc — Core facies of the Passadumkeag River pluton
- Dwcr — Rim facies of the Whitney Cove pluton
- Dwcc — Core facies of the Whitney Cove pluton
- Da — Amphibolite

SYMBOLS

- Foliation, inclined, vertical
- Joint, inclined, vertical
- Dike, inclined, vertical
- Contact, dashed where approximate
- Fault, dashed where approximate (Note that heavy solid lines are also used for contacts in pluton and pluton margin.)