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Title: Bedrock Geology of the State of Maine Portion of the Sherbrooke 2 degree Quadrangle (1980) and Transverse Faults in the East Central Part of the Sherbrooke 2 degree Quadrangle (1981).

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BEDROCK GEOLOGY OF THE STATE OF MAINE PORTION OF THE SHERBROOKE 2-DEGREE QUADRANGLE

BY

GARY M. BOONE

1980

INTRODUCTION

Reports of the previous two years on the bedrock geology of the Sherbrooke 2-degree Quadrangle were based on a lithologic, rather than a stratigraphic, compilation. Stratigraphic order and correlation of units in the State of Maine portion of the map are now well enough established that a preliminary attempt can be made here to place some age limits, albeit wide ranging, on structures resulting from brittle deformation. Faults and related kink bands transverse to regional and local strike are apparently more widespread than are strike faults. Magnitude of displacement, and even sense of net displacement on two major strike fault systems, are imperfectly understood. Minor post-Pleistocene thrust faulting is documented near the southeast corner of the map area. Westerman (1979; this volume) studied the Woburn, Quebec, area and discussed the possibility that recent earthquake activity may be related to inferred faults shown on his map of the region.

The following discussion attempts to (1) review and bring up to date the existing knowledge of brittle deformation in the State of Maine portion of the map, (2) postulate causes of deformation, and (3) suggest locations of probable seismic hazard.

ACKNOWLEDGMENTS

Maps, theses, and reports produced by several people during the past two decades are compiled herein (cf. area key on map and references, this report). Discussions with each of them during my own mapping in the region have been fundamental to the present synthesis. I am especially grateful to Eugene Boudette and Robert Moench, with whom I have collaborated for many years. David Westerman has focused attention on the problematics of origin of the fault systems along the Maine-Quebec border. Funding has been provided by the U.S. Nuclear Regulatory Commission through the Maine Geological Survey. I am grateful to Walter Anderson, State Geologist, and Woodrow Thompson, Assistant State Geologist, for many aspects of support and to Robert Tucker for drafting the final map copy.

STRATIGRAPHIC SUMMARY

In keeping with the purpose of this report only generalized rock-stratigraphic features and contrasts are mentioned. With the exception of the Moose River synclinorial belt (wedge of DSu, east-central part of map) the regional structure is broadly homoclinal, giving overall younger formational ages from the Woburn-Chain Lakes area of the international boundary east-southeastward to the vicinity of the Bigelow Range and Carrabasset Valley. Formations range in age from Precambrian to Devonian. They are variously metamorphosed from chlorite-muscovite grade to granulite grade. Partial retrograding of the higher-temperature mineral assemblages is common; this effect is widespread and is not specifically or solely related to zones of brittle deformation.

The Chain Lakes massif (Boudette and Boone, 1976) is unique in the lithologic spectrum of the region. It is composed mainly of feldspathic and semi-pelitic gneisses and granofels of Precambrian age which have been affected by a complex history of deformation and metamorphism. Both polymicitic and monomictic rock fragment and boulder assemblages are common in the gneisses and granofels. A late, pervasive retrograde metamorphism contributed to the evolving structural integrity of the massif as well as to its erosional resistance marked by several of the highest peaks in the Boundary Mountains. Bordering the massif to the south is an ophiolitic suite, the Boil Mountain Ophiolite (Boudette, 1978; 1979), dipping and facing to the south and apparently affected by the same retrograde event.

Flanking these rocks to the south and east is a strike belt of three related pre-Silurian (probably pre-Ordovician) tectonostratigraphic units extending from northern New Hampshire to north central Maine. This belt, northward from the latitude of 45° 15', is often cited as the northern extension of the Boundary Mountains anticlinorium although the exposed structure is predominantly homoclinal.

The formations concerned are: Jim Pond Formation, composed of mafic volcanic and volcaniclastic rocks with subordinate intermediate and felsic rocks, slate, and graywacke. Thin beds and lenticles of hematiferous schist and chert mark the upward transition into the Hurricane Mountain Formation of rusty metasiltstone with felsic volcaniclastic laminae. Roughly strike-parallel zones of polymictic mélange facies are common. Hackly, anastomosing microfractures pervade the metasiltstone matrix of the formation throughout the strike belt. The Dead River Formation overlies the Hurricane Mountain; it consists of a flysch sequence of pin-striped metapelite and volcaniclastic graywacke. Both lithic components are strongly polydeformed, showing at least three stages of cleavage development accompanying transposition of older s-surfaces (Burroughs, 1979). However, the Dead River Formation lacks the chaotic internal microstructural complexity of the Hurricane Mountain Formation. All three formations underlie, in apparent unconformity, fossiliferous Lower to Middle Ordovician strata of much lesser structural complexity in the southwestern part of the Millinocket 2-degree quadrangle, adjacent to the Sherbrooke Quadrangle.

Southeast of the strike-parallel line of dominantly mafic igneous complexes extending from the South Branch of the Dead River (north of Rangeley) northeastward across Flagstaff Lake to the Pierce Pond gabbroic intrusion near the eastern margin of the Sherbrooke map at 45° 15', lies an intrusion-punctuated tract of 14 metasedimentary formations ranging in age from Middle or Late Ordovician to Early Devonian (cf. map). The lithology of these formations is sufficiently summarized in the map explanation such that, for this report, they may be collectively commented upon as a coherent sedimentological and structural volume of rock affected only by the Acadian orogeny and attendant localized intrusion-tectonics. Pelites and semipelites dominate this sequence. Volcanic and volcaniclastic rocks are notable for their absence. Metamorphism is expressed in localized hornfels rims concentric to intrusive contacts in the northwestern part of this tract, merging into Buchan-style regional metamorphic gradients to the south and east. Trend-lines expressing plastic deformation of the metasedimentary formations are shown in the extreme southeastern part of the map.

Devonian (late Acadian) intrusions predominate over those of older age in the Sherbrooke Quadrangle. Although more numerous in the southeast, they occur throughout the region covered by the map boundaries. Structural modifications by both gabbroic and granitic intrusions were largely controlled by the pre-intrusive deformational history of the host rocks. The Attean batholith (Oat on map) is the only pre-Acadian intrusion of major areal extent. Its structural and metamorphic effects on Chain Lakes massif host rock are surprisingly minimal.

STRUCTURAL DOMAINS OF BRITTLE DEFORMATION

Three domains are recognized within the State of Maine portion of the map. They conform in large measure to the areas underlain by the three stratigraphic divisions outlined in the previous section: (1) the structural block of the Precambrian Chain Lakes massif; (2) the strike belt of polydeformed, arc-and-trench related, Cambrian (?) strata consisting of the Jim Pond, Hurricane Mountain, and Dead River formations; and (3) the area of Acadian plastic deformation, medium to high grade metamorphism, and intrusion shown in the southeast corner of the map.

Chain Lakes block

In terms of response to brittle deformation, the Ordovician and Devonian granitic plutons bordering on and intrusive into the Chain Lakes massif are part of this domain. Absence of fault traces in the central part of the Chain Lakes massif in part must reflect lack of detailed mapping, but also in part must reflect the comparative coherence, and thus resistance, of rocks in this terrain to brittle deformation. The lack of extensive photo-linears on satellite imagery of the central part corroborates this interpretation. In outcrop, evidence of minor movement on fracture surfaces abounds, and is apparently ubiquitous throughout the Chain Lakes massif and Attean batholith. But just as evident is the retrograde healing of fractures by epidote, feldspar, or quartz vein material which commonly has not been subsequently sheared. Texture, composition, and microstructure of veins in the massif and batholith are similar, but there is no reason to believe that the vein-forming events were coeval, as the retrograde metamorphic cooling of the massif must have long pre-dated the post-magmatic, deuteric activity of the cooling batholith. The first event was probably Precambrian; the second, presumably Ordovician. The structural coherence of the Chain Lakes massif is disrupted along its southern and southeastern margin by discontinuous narrow zones of spaced cleavage superimposed on earlier structures, and by cross-faulting. Similar behavior is documented along the northwest margin of the massif. Structures such as these carry across the massif boundaries into the Cambrian (?) deformed and mildly metamorphosed strata south of the massif, and into Cambrian (?) and Devonian strata northwest of the massif. Thus these structures cannot be older than the initial deformation of the Cambrian (?) rocks to the south, or older than the folding of the Cambrian (?) and Devonian rocks to the northwest of the massif.

The strike-fault-bounded northwest margin of the massif continues to be problematic in origin, as the fault surfaces are not exposed. Westerman (1979) has argued for a predominantly normal-fault sense of displacement, while Boone (1978) and others have noted microstructures in the Attean batholith and bounding younger phyllite of Seboomook age indicating compressive stress roughly perpendicular to the strike of the fault zone. Thus they inferred that thrusting was the major sense of displacement. Dip direction of a thrust fault surface is equivocal with respect to interpretation of the microstructures studied. In regard to postulated thrust faulting, younger metasedimentary rocks may have been thrust southeastward over older rocks of the Chain Lakes structural domain. Alternatively, metasedimentary rocks may have been involved in a tectonic slide northwestward over the Chain Lakes domain, followed by rotation of the slide surface by open folding.

The fault-bounded northwest margin of the Chain Lakes domain is parallel to the Seboomook Formation - Frontenac contact. Boucot (1961) and Albee and Boudette (1972) considered the Frontenac to lie in depositional conformity upon the Seboomook. However, it is conceivable that the contact is a fault, as small-scale chevron folds and shear surfaces in the Seboomook Formation become abundant close to the contact, and the contact zone is expressed topographically by low-lying terrain ranging in cross-strike width from a half to somewhat more than a kilometer. The alternative hypotheses of thrust faulting, given in the preceding paragraph, apply equally to the Seboomook - Frontenac contact. E.L. Boudette (personal communication) favors the hypothesis of a pre-Silurian age for the Frontenac, and northwestward thrusting of the Frontenac over the Seboomook Formation and subjacent older rocks of the Chain Lakes structural domain.

Since strata as young as Early Devonian are involved, deformation is assigned to the Acadian orogeny and possibly younger faulting. The length of the paired fault zone is a least 90 km (56 miles). It is recognized from the vicinity of Boundary Bald Mountain due north of the Attean batholith, southwestward along the international boundary, across the Devonian granites of Spider Lake and Seven Ponds, and is believed to extend into northernmost New Hampshire. Mapping during the 1980 field season in northern New Hampshire and in the Penobscot Lake 15-minute Quadrangle (NE corner of the Sherbrooke map) may clarify further the nature and extent of this zone.

Strike belt of polydeformed Cambrian (?) metavolcanic and metasedimentary rocks

This belt displays varied styles of deformation depending upon its proximity to gabbroic intrusive rocks of Acadian and post-Acadian age. The development of polydeformed microstructures in strata of this belt is roughly uniform over great distance along its strike: from north-central Maine to New Hampshire. Although the younger (metasedimentary) formations are repeated by folding across the strike belt, the oldest (metavolcanic) formation is restricted to the northwest side of this belt. Thus the central part of the belt in the western Maine half of the Sherbrooke map is steeply homoclinal, facing southeast toward the Dead River Formation. North of a strike-parallel belt of intrusive gabbro and minor granite (extending northward from 70° 45' at the south margin of the map) the younger two Cambrian (?) formations are repeated across strike by folding and involved in several thrust faults with a northwestward sense of upper plate displacement. The folds and thrusts are offset by abundant northwest-striking transverse faults. Both strike-slip and dip-slip movements took place variously on faults of this system. Inasmuch as some of the faults offset the Silurian and Devonian rocks of the Moose River synclinorium (DSu on map) and offset the igneous rock contacts (Dga and Dgr) they are post Early to Middle Devonian in age. Because of their proximity to the Devonian intrusive rocks, both the thrust faults and the transverse faults which offset the thrust fault contacts are inferred to have been produced by the process of intrusion of gabbro and granite of Early to Middle Devonian age (Boone, 1973). Where gabbro and granite are in thrust faulted contact with the Cambrian (?) strata northeast of longitude 70° 30', and with Ordovician and Silurian strata to the southwest, the contact metamorphic aureole, which is so prominently developed elsewhere around these intrusives, apparently was overidden by the rocks of the upper plate.

Conjugate faults south of the ophiolitic rocks bordering the Chain Lakes structural block record upper plate deformation probably related to the thrusting of the Cambrian (?) strata northward toward the ophiolitic complex (Boudette, 1978).

Granitic plutons in this strike belt which lack intermediate and mafic associated rocks also lack spatially related thrusts in neighboring host rock. Devonian granite stocks in the southwestern part of the map and the northern lobe of a granite batholith shown along the southeast margin are examples.

Southeastern terrain of Acadian complex folding, medium to high grade metamorphism, and igneous intrusion

Crowding of wall rocks during the period of late to post - Acadian igneous intrusion continued to be a dominant structural process in this area, as it was in the Cambrian (?) strike belt to the northwest. Whereas faulting was predominant in the latter area, strain is expressed mainly by coherent plastic deformation in the southeastern terrain, where concomitant metamorphism was more intense, and where lithostatic and fluid pressures were greater. In effect the Upper Ordovician to Lower Devonian strata constitute a deformed, southward-thickening wedge of turbidites affected by a single, evolving episode of complex folding, intrusion of mesozonal plutons, and accompanying polythermal metamorphism. Brittle deformation is expressed almost solely by pervasive regional joints, as is also the case in the two structural domains to the north. Joints making up this system are dominated by a steep, northwesterly striking (290^{o} - 320^{o}) set which is expressed by closer spacing of fractures than are the other sets. The other sets are composed of gently south-dipping fractures modified by locally controlled, topographically related sheeting, and conjugate sets, also apparently locally controlled, and either steeply or gently intersecting symmetrically across axial surface orientations. The northwesterly-striking set (or sets?) is also parallel to zones of kink-banding in which the pervasive axial-plane cleavage of the metamorphic rocks is transposed into a northwest-striking slip cleavage. Northwest-striking joints are also more prominent and more closely spaced in the gabbroic and granitic plutons of the regions.

Locally, joints are in apparent random orientations, showing little consistency from one locality to another. Burroughs (1979) describes one such area in a sheared portion of the Ordovician Attean batholith, bordering the fault-bounded roof remnant of Chain Lakes granofels.

REGIONAL SIGNIFICANCE OF BRITTLE DEFORMATION

In the State of Maine portion of the Sherbrooke map, it is significant that, as brittle-fracture study proceeds, those of us mapping in this region continue to document extensions of previously-mapped northwest-striking faults (Boone 1973; Koller 1979; Burroughs 1979) and to further record the prevalence and intensity of northwest-striking joints and zones of slip-cleavage. Although many of these faults appear to be related to intrusive crowding in the central strike-belt realm of brittle deformation, not all of this family of northwesterly oriented faults can be so generated. Cross faults along the northwest boundary of the Chain Lakes structural domain are an example. Also, it now appears likely that the Dead River fault, shown by Koller (1979) to extend into the northern lobe of the Lexington batholith (southeast margin of map), may also extend northwestward as one or more closely related fault surfaces, across the strike belt of Cambrian (?) rocks, across the Moose River synclinorium, the western margin of the Attean batholith, and the eastern part of the Chain Lakes massif. The distance is somewhat greater than 60 km. Even as presently shown on the map, it is a major structural feature of regional extent. It is speculative to propose that ancestral brittle structures in Chain Lakes or other basement rocks were propagated upward into younger rocks during periods of reactivation, but this must be considered as a likely mechanism in estimating the likelihood of renewal of faulting along existing structures. Long Falls Dam, Flagstaff Lake, is located within approximately 300 to 400 meters of the Dead River Fault.

POST - PLEISTOCENE FAULTING

Just off the southeast corner of the map, a glacially polished bedrock surface is broken by two strike-parallel thrust faults, each of approximately 15 cm displacement. The faults are about one meter apart, dip northwestward at 40°, and cut across the schistosity of the wall rocks, which in turn dips northwestward at 85°. The sense of displacement is similar to that recorded by Block and others (1979) in Connecticut, but the dip of the fault surfaces is much steeper.

SEISMIC RISK

Potential displacement and risk to Long Falls Dam at the outlet of Flagstaff Lake has already been mentioned. This dam is one of three major controls in the Kennebec watershed operated by Central Maine Power Company. Although not in the Sherbrooke map area, the Harris Dam, at the outlet of Indian Pond, on the upper Kennebec, is under similar risk. Inasmuch as the waters from these two dams converge at the confluence of the Dead River and upper Kennebec River at The Forks, the potential risk of flooding is intensified on the river downstream from The Forks.

Reactivation of faults throughout the strike-belt of Cambrian (?) rocks must be considered as a higher seismic risk than faulting elsewhere in the eastern half of the Sherbrooke map.

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TRANSVERSE FAULTS IN THE EAST CENTRAL PART OF THE SHERBROOKE 2-DEGREE QUADRANGLE

BY

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1981

Northwesterly striking transverse faults in the area covered by the State of Maine portion of the Sherbrooke 2-degree Quadrangle are particularly well documented in pre-Silurian rocks (Boone, 1973; 1979; Boudette and Boone, 1976; Burroughs, 1979).

Since it has not been possible to document a similar abundance of transverse faults in the Silurian - Devonian terrain of the Moose River synclinorium, the problem of the age of these faults and their tectonic origin has continued unresolved. Certain transverse faults in the strike belt of pre-Silurian rocks bounding the Moose River synclinorium on its southeast margin give the appearance of being pre-Silurian because they are truncated by the Squirtgun Fault which defines this margin. The Squirtgun Fault is a strike fault with regard to the Silurian and Devonian rocks of the synclinorium, but is only approximately so with regard to the trends of the adjacent pre-Silurian formations. Other transverse faults offset this fault boundary. Although transverse faults break the strike continuity of formational units throughout the belt of pre-Silurian rocks, few, if any are known to transect the synclinorium. Burroughs (1979) extended southward across the southwest end of the Moose River synclinorium the trace of a transverse fault cutting formational units ranging in age from Precambrian to Devonian in the Spencer Lake quadrangle, basing his inference on (1) termination of the Upper Silurian Parker Bog Formation against the north and south boundaries of the synclinorium, (2) an abrupt bend, or offset, along the south boundary in the same vicinity, and (3) a low-relief topographic lineament along the extended trace.

Despite lack of exposure in a more centrally located transverse valley of the synclinorium occupied in part by Enchanted Pond, I have extended the trace of a prominent transverse fault from the pre-Silurian belt, where it is well documented, across the synclinorium in this locality. Extension is based on offset ridge lines recorded in 1:40,000 scale infrared photography. The offset pattern across the Enchanted Pond valley is inferred to be structural because it is not an artifact of any major difference in crest-line elevations across the valley, nor of any known difference in lithology along the trends of north- and south-dipping strata of the Tarratine and Tomhegan formations. This inferred fault line is in approximate alignment with a second fault documented by Burroughs (1979) which cuts the Chain Lakes massif and Attean granitic rocks across the southern part of Spencer Lake.

These relationships suggest the possibility that all the transverse faults of the east-central Sherbrooke map area may have occurred as manifestations of one tectonic regime. I postulated in earlier reports (Boone, 1978; 1979) that emplacement of the post-Acadian Pierce Pond gabbroic intrusion and bimodal gabbro-granite suite of the Flagstaff Lake Igneous Complex produced ductile deformation in the Silurian and Devonian strata in simply folded Acadian structures south of these complexes, and largely brittle deformation in the polydeformed pre-Silurian rocks north of them. Clearly the greatest concentration of transverse faults lies in the tract of the pre-Silurian rocks where it is proximal to these igneous complexes. It is unlikely, however, that structural adjustment attendant upon emplacement of these post-Acadian plutons is the sole cause of transverse faulting in this region, because the intrusive contacts are offset along several of the faults.

Faults of similar orientation and length, with dip-slip major components of displacement, extend both to the northwest and to the south of the aforementioned belt of intrusives. Two of these faults are located several miles to the northwest of the tract described, well separated from exposures and contact metamorphic expressions of post-Acadian intrusives. A third fault offsets the trace of the Northwest Boundary fault. Therefore, some of these faults, at least, or some of the movement (posthumous?) on many of the transcurrent faults, may be related to regional adjustments attending post-orogenic, mid- to late-Paleozoic strike-slip faulting throughout the northern Appalachians; and the adjustment to post-Acadian igneous intrusions may have been but a precursor to further regional post-tectonic deformation.

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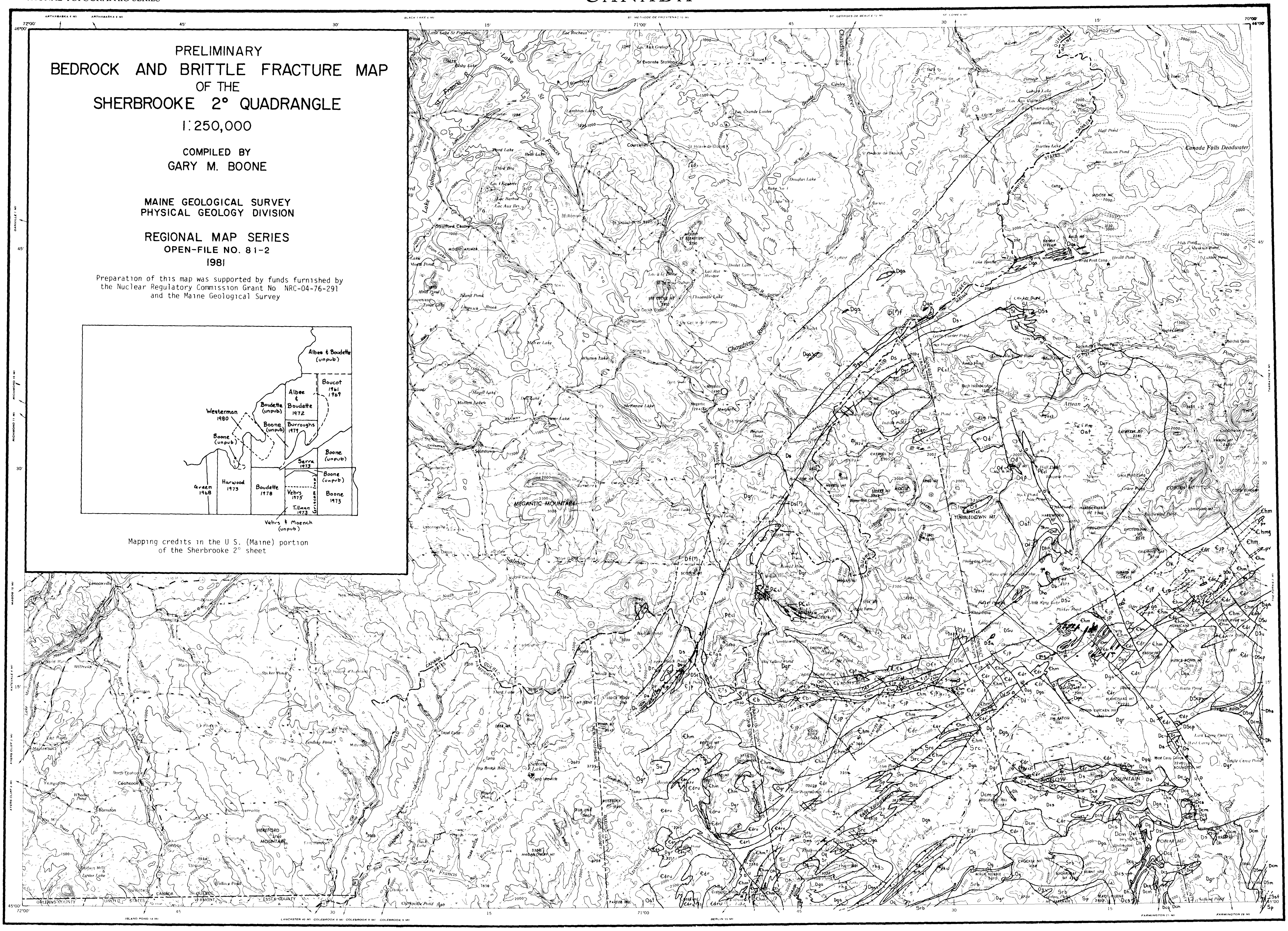

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from the first edition of the 1:250,000 Sherbrooke
map sheet prepared by the Corps of Engineers,
U.S. ARMY MAP SERVICE.

SHERBROOKE

CANADA AND UNITED STATES

Contour interval 100 feet
All Elevations in feet above mean Sea Level
Universal Transverse Mercator Projection

(Note: this map excludes Silurian and Devonian formation detail in the Moose River synclinorium, in addition to units west of the Frontenac Formation in Quebec and Maine. Bedrock geology in the northern New Hampshire portion of the map is not shown owing to extensive ongoing re-investigation of that area.)

EXPLANATION

Dgr Biotite and hornblende-bearing, porphyritic, subporphyritic, and subequigranular granite and granodiorite. Sparse aplite and pegmatite. Dr: hypabyssal or extrusive equivalent

Dga Fine-, medium-, and coarse-grained subequigranular gabbro, dolerite (Dd), troctolite, and diorite. Locally biotite-bearing. Minor associated mafic rock types. Sparse albite-chlorite-biotite pegmatite.

rhg Reaction hornfels, commonly garnetiferous.

ga Medium- to coarse-grained gabbro and dolerite of undetermined age, but texturally similar to Devonian rock of corresponding composition.

Ds, Dsl Seboomook Formation
Upper member: Gray, cyclically graded-bedded metagraywacke and metapelite. Graded-bedded units commonly 10-15 cm thick but ranging from 5 cm to a meter. Meta graywacke and metapelite in subequal proportions

Lower Member: Gray to light gray parallel-bedded and cyclically graded-bedded metapelite and metagraywacke. Graded sets, 5-30 cm thick.

Dh, Dhs Hildreths Formation
Upper member: Green, violet and white, thin- to medium-layered, iron sulfide-bearing calc-silicate rock interbedded with, and grading laterally into iron sulfide-bearing, dark gray, non-porphyroblastic muscovite-biotite schist. Rusty weathering characteristic of all lithic types except locally for calc-silicate rock portions north of Huston Brook. Sparse thinly to thickly bedded greenish gray and violet calc-silicate-bearing quartzite. Locally dark gray to black, pyritiferous slate northeast of Lexington batholith (Dhs).

Carrabassett Formation

Dcs Thinly layered schist member: Gray to light gray, thinly layered and laminated, andalusite-cordierite schist and non-porphyroblastic quartz-rich schist and phyllonite. Sparse staurolite pseudomorphs in subporphyroblastic layers. Predominantly parallel-bedded; relict graded bedding poorly developed or preserved.

Dcq Metaquartzite member: Gray to dark gray, biotite-bearing, variously feldspathic, thickly bedded metaquartzite. Minor thick zones of massive gray, muscovite-rich schist, variously porphyroblastic.

Dcm Massive metapelite member: Gray, muscovite-chlorite slate and muscovite-biotite-rich slate, andalusite-staurolite schist, gneissic sillimanitic granofels, and phyllonite with abundant pseudomorphs of andalusite and staurolite porphyroblasts. Quartz-rich segregation-laminae abundantly developed parallel to axial plane cleavage. Sparse relict medium to thick parallel bedding manifested by slight and indistinct compositional variations. Sparse sulfide-quartz lenticles. Restricted sections, up to 20 m thick, of graded-bedded 3-20 cm-thick sets of metapelitic rock and metagraywacke.

Dho Hobbstown Formation. Arkose and conglomerate.

DScp Calcareous phyllite and calc-silicate rock.
Gray to greenish gray, buff weathering, calcite-and ferroan dolomite-bearing phyllite; subordinate thick lenses of medium-bedded, light gray fossiliferous limestone. Metamorphosed to green, violet, and subordinate white calc-silicate rock, unevenly layered, in northern aureole of Lexington batholith.

DSs Conglomeratic sandstone

DOf Frontenac Formation. (Listed as Devonian by Marleau, 1968; Albee and Boudette, 1972; and Boucot, 1961 & 1969)
Fine- to medium-grained greenish-gray slightly calcareous argillaceous sandstone and chloritic phyllite and slate

Sl Limestone and calcareous slate.

Shm Hardwood Mountain Formation. Dark calcareous sandstone, slate, limestone conglomerate, and limestone.

DSa Mafic agglomerate and volcanic breccia.

DSm Madrid Formation
Lower part: green, violet, and light gray, thinly layered calc-silicate rock. layers separated by micaceous partings; sparse thin layers and laminae of biotite-muscovite schist. Middle and upper parts: thinly to thickly bedded, light gray to purplish gray, biotite-plagioclase metaquartzite, subordinate massive to schistose metaquartzwacke. Carbonate-bearing at chlorite grade; calc-silicate-bearing at higher grades. Dominantly parallel-bedded, graded beds and small-scale cross-beds abundant locally. Diffuse to sharply zoned calc-silicate pods and cylinders abundant locally.

DSu Silurian & Devonian pelitic and calcareous metasedimentary rocks undivided.

Ssf Smalls Falls Formation
Black, rusty-weathering, pyrrhotitic metapelitic rock and fine-grained metaquartzite. Thin to medium parallel-bedded, subordinate indistinct graded bedding.

Sp Perry Mountain Formation
Silvery gray, muscovite-rich metapelitic rock and light gray metaquartzwacke and metaquartzite. Muscovite-rich, sillimanite-almandite-bearing granofels in southwest corner, Little Bigelow Mountain Quadrangle. Thin to medium parallel-bedded and cyclically graded bedded.

Sr (a,b,c) Rangeley Formation
Gray metapelite, fine- to medium-bedded feldspathic metasandstone. Beds with internal laminations; subordinate cyclic bedding. Locally calc-silicate rock and psammitic metalimestone, fossiliferous near Lutton Brook. Locally polymictic metaconglomerate, grading into subordinate brown, fine- to medium-grained calcareous, chloritic metasandstone and metapelite.

Og Greenvale Cove Formation
(Upper Ordovician (?)) - Interlaminated light gray fine- to medium-grained quartzose metasandstone, medium gray metasiltstone, and gray metapelite characterized by 0.5 - 8 cm beds which are cross-laminated; sparse lenticular beds of light gray medium to coarse-grained quartzose metasandstone up to 1 m thick.

Oq Quimby Formation
Cyclically-bedded gray to dark gray metapelite, commonly sulfidic, and metagraywacke. Minor conglomerate and felsic metavolcanic rock.

Ok Kamankeag Formation
Black, sulfidic metapelite and metasiltstone, with thin medium beds of metagraywacke. Sparse greenstone lenses.

Oat Attean batholith
Granite and granodiorite, biotite- and hornblende-bearing where fresh; commonly porphyritic to subporphyritic with phenocrysts of microcline perthite and subordinate plagioclase. Quartz phenocrystic near margin. Dominantly coarse-grained, but fine-grained and becoming aphanitic locally against Chain Lakes massif. All rock types are commonly altered to chlorite-grade mineral assemblages but largely retaining relict igneous textures.

Ot,Od Tonalite; altered dacitic rocks. Coeval or possibly older than Oat.

Ogr Unnamed granitic rocks, commonly altered.

s Allochthonous serpentinite. Primary age possibly Cambrian; time of latest tectonic movement not known. Mottled dark green and white talcose chrysotile-bearing highly sheared serpentinite found along faults commonly associated with a border of talc and quartz-Mg-carbonate-fuchsite vein rock.

Cambrian (?)

€dr Dead River Formation
Chlorite-rich metapelitic rock and metagraywacke, ranging from silvery light green to dark green phyllite and coarse-to fine-grained, buff white-weathering metagraywacke at low metamorphic grades, to brownish-gray knotenschiefer, and to gray to dark violet, brown-weathering, cordierite-rich, massive to weakly gneissic granofels and dark metagraywacke at medium and high metamorphic grades. Lower and middle parts: thin to medium parallel-bedded; graded and wavy bedding poorly defined. Pelitic compositions predominant. Upper part: thinly to very thickly bedded, parallel-bedded sections alternate with sections up to 10 m thick, of wavy bedding and graded bedding. Slump structures, "sand" dikes and sills, and other relict soft-sediment deformational features Subequal proportions of pelitic and graywacke compositions.
Metapelitic rocks in all parts of the formation and in all metamorphic zones characterized by quartz and quartz-feldspar pin-striping parallel to cleavage, schistose and gneissic foliation, and relict bedding.

€hm Hurricane Mountain Formation
Gray to dark gray and black metapelite and metasiltstone, commonly pyritic, with subordinate laminae of white to buff, fine-grained felsic metavolcaniclastic rock Lenses and sparse discrete beds of metagraywacke. Lenses and laminae commonly sheared and microfaulted. Fine-grained rocks commonly contain a pervasive, complex hackly microfractured fabric. Locally lithic clasts, ranging from pebble size to boulders and rafts, are abundant; collectively such zones, roughly strike-parallel, contain a polymictic assemblage of graywacke, quartzwacke, dark grayish blue orthoquartzite, light gray feldspathic quartzite, amphibolite, metadolerite, light brown weathering impure limestone, granite, and psammitic schist, listed in decreasing order of abundance.

€jp Jim Pond Formation
Mafic and felsic volcanic and volcaniclastic rocks. Interbedded medium- to coarse-grained metagraywacke and metaquartzwacke, dark gray slate, minor cherty lenses. Thin lenses of ferromanganese oxides and gray chert common at top.

€bm Boil Mountain Ophiolite
Epidiorite, clinopyroxenite, altered pyroxenite & serpentinite. Grades into pillowed greenstone and associated rocks of the Jim Pond Formation. (C(?)t: minor tonalitic rocks.

P€cl Chain Lakes massif
Quartzofeldspathic granofels with relict volcanic (?) and volcaniclastic (?) structures. Polydeformed pelitic and semipelitic gneiss with widespread flecky gneiss microstructure. Minor amphibolite and psammitic gneiss. Retrograde metamorphism widespread.