Geology of the Wittenburg Mountain Slate Belt, Centre Musquodoboit Area (NTS 11E/03), Nova Scotia

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Regional Geology

Wittenburg Mountain is located in the central Meguma Terrane of southern Nova Scotia (Fig. 1). The Meguma Terrane is dominated by metamorphosed sedimentary rocks of the Meguma Group and overlying Ordovician-Lower Devonian units, and Devonian to Carboniferous granitoids. The Meguma Group includes the lower, metasandstone-dominated Goldenville Formation and the overlying, slate-dominated Halifax Formation. The metamorphic rocks are folded into regional-scale northeast-trending folds, and at the current level of exposure the Goldenville Formation is exposed mainly in anticlinoria and the Halifax Formation and younger rocks in synclinoria, the latter defining slate belts. Granitoid plutons intrude the Meguma Group and truncate regional folds. Carboniferous sediments unconformably overlie the older rocks. Several regional-scale faults truncate all rock units in the area.

Digital elevation models and high resolution aeromagnetic data suggest geological similarities between the Wittenburg Mountain and Rawdon Hills slate belts in the central Meguma Terrane (Fig. 2). Recent mapping of the Rawdon Hills slate belt has provided detailed stratigraphic and structural data which can be related to the digital elevation and aeromagnetic data. In particular, the aeromagnetic data correspond to distinct lithologic units within the Halifax Formation, with high magnetic response corresponding to the lower Cunard Member and relatively low response to the upper Glen Brook Member (Horne and King, 1992; Fig. 2c). Digital elevation data indicate the Rawdon Hills slate belt defines a northeast-trending topographic high (Fig. 2b). Mapping has defined regional-scale faults on both margins of the slate belt, with a slate-belt-up sense of movement; thus, the slate belt defines a horst structure (Fig. 2b; Horne et al., 1997).

Figure 1. Simplified geological map of the Meguma Terrane showing the location of the study area.
Similarities between the Rawdon Hills and Wittenburg Mountain slate belts are evident in the digital elevation models (DEM) and aeromagnetic data (Fig. 2). The aeromagnetic response suggests similar stratigraphy for both the Wittenburg Mountain slate belt and the Rawdon Hills slate belt, and the DEM data suggest the Wittenburg Mountain slate belt may also represent a horst structure. The following study presents the results from geological mapping of the Wittenburg Mountain slate belt in the Centre Musquodoboit area (Figs. 2, 3). The objective of the study was to evaluate the stratigraphy of the Halifax Formation and the possibility of faults at the margins of the slate belt, and thus evaluate the use of digital elevation models and aeromagnetic data as predictive tools for extending the details of recently mapped areas into areas where less detail has been established.

Wittenburg Mountain Slate Belt

Stratigraphy

The map area is underlain entirely by rocks of the Halifax Formation, which is undivided on previous maps (Faribault, 1899; Stevenson, 1959). The Halifax Formation has been subdivided during this study into the lower Cunard Member and overlying Glen Brook Member (Fig. 3). The Cunard Member consists of dark slate and lesser metasiltstone beds. Metasiltstone beds are typically cross-bedded and generally range from 2-30 cm in thickness; however, thicker beds occur locally. The Cunard Member is typically sulphide-rich with coarse pyrite and pyrrhotite occurring in slate and metasiltstone intervals. This unit corresponds to the areas of elevated aeromagnetic response along the margins of the Wittenburg Mountain slate belt (Fig. 2c).

The Glen Brook Member consists of green to grey, thinly bedded metasiltstone and slate. Colour variation between slate (generally grey) and metasiltstone (light grey-green) beds commonly results in a distinct colour banding. Metasiltstone beds are commonly cross-bedded, whereas slate beds are planar bedded. Locally, decimetre- to metre-thick metasandstone beds occur within this unit. The Glen Brook Member does not contain notable amounts of sulphide minerals and corresponds to the areas of relatively low aeromagnetic response in the centre of the Wittenburg Mountain slate belt (Fig. 2c).

Legend (Fig. 2)

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Abbreviations

- RHNSB --- Rawdon Hills Slate Belt
- WMSB --- Wittenburg Mountain Slate Belt
- RF --- Rawdon Fault
- RCF --- Roulston Corner Fault
- MF --- Meadowvale Fault
- MV --- Musquodoboit Valley Fault
- MB --- Musquodoboit Basin

Structure

Regional Folds

The Wittenburg Mountain slate belt consists of a kilometre-scale synclinorium, herein referred to as the Wittenburg synclinorium. The overall synclinal form of the slate belt is supported by repetition of the lower Cunard Member on both margins (limbs; Fig. 3), as reflected in the aeromagnetic data (Fig. 2c). Three folds occur within the Glen Brook Member, including the South Branch Stewiacke Anticline (Faribault, 1899) and two unnamed synclines (Fig. 3). Bedding-cleavage relations and sedimentary structures indicate that all folds are upward facing. A well-developed continuous to spaced cleavage is axial planar to the regional folds. The typically steep dip of cleavage (Figs. 3, 4) indicates folds are steeply inclined. Fold hinges (bedding-cleavage intersection) in the map area plunge moderately to the northeast and southwest (Figs. 3, 4b).
Figure 2. (a) Map of the central Meguma Terrane showing the geological setting of the study area. (b) Digital elevation data for the area shown in (a) showing the elevated, fault-bounded plateaus represented by the Rawdon Hills and Wittenburg Mountain slate belts. (c) Map of aeromagnetic data for the area shown in (a). Note how the geology of the Rawdon Hills (after Horne, 1993, 1995) and Wittenburg Mountain (for area of Fig. 3) slate belts correspond to aeromagnetic data.
Figure 3. Geology of the map area, showing the location of sections lines A-B and C-D in Figure 5.
Wittenburg Mountain slate belt and the Musquodoboit Basin is supported by diamond-drilling, which shows thick intervals of Middle Carboniferous Windsor Group sediments and a general lack of Lower Carboniferous Horton Group sediments adjacent to the slate belt (Hannon, 1974; Nash, 1975). Recent shallow seismic data indicate faulting of Cretaceous sediments in the area of the proposed fault (Fig. 2a), with a slate-belt-up sense of movement (Stea and Pullen, 1998). The name Musquodoboit Valley Fault (MVF) is used herein for a proposed fault along the southern margin of the Wittenburg Mountain slate belt (Figs. 2, 3).

Recent mapping has documented a wide zone of fault-related deformation affecting the Halifax Formation along the southern margin of the Wittenburg Mountain slate belt, supporting the presence of the Musquodoboit Valley Fault. The nature of this deformation is similar to that defined for the Rawdon Fault (Horne, 1993; Horne et al., 1997) and defined by a regional-scale, fault-related fold, marginal to the fault. Within the fault zone, the southern limb of the Wittenburg synclinorium has been folded downward (i.e. southward), consistent with north-side-up, dip-slip movement on the Musquodoboit Valley Fault (Fig. 5). The bedding-cleavage angle is constant across the fold (Fig. 5a), suggesting a post-regional folding, fault-related origin for folding. At the outcrop scale, deformation is mainly restricted to bedding-parallel faults. Meso-scale folds related to bedding-parallel faults are locally exposed and show an extensional sense of movement (Fig. 6; i.e., top to the northwest on northwest- dipping beds). Crenulation cleavage is developed within some bedding-parallel faults, also indicating an extensional sense of movement (Fig. 6d). Limited fold data (Fig. 4c) show a southwest plunge to fault-related folds, possibly indicating oblique displacement with a dextral component of slip. However, limited striae on bedding-parallel movement surfaces within the fault record mainly dip-slip movement (Fig. 4d).

Figure 4b shows a possible model for the Musquodoboit Valley Fault, with north-side-up displacement resulting in a fault-related, kink-style fold where bedding was rotated down toward the south. Cretaceous sediments (K) straddling the fault are deformed by similar fault-related folds; however, Pleistocene till (P) unconformably overlies the deformed Cretaceous sediments (Fig. 5b; Stea and Pullen, 1998). This kink-fold model accounts for the abrupt rotation of bedding within the fault zone and the sense of shear on bedding-parallel faults within the rotated limb of the fold.

Musquodoboit Valley Fault

Boehner (1977) proposed that a steep fault defines the contact between Carboniferous rocks of the Musquodoboit Basin and the Wittenburg Mountain slate belt, which he referred to as the North Border Fault. As mentioned above, the Wittenburg Mountain slate belt defines an elevated block which, based on comparison with the Rawdon Hills slate belt, likely represents a fault-bounded horst. The presence of a fault between the

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**Figure 4.** Stereoplots of (a) bedding and (b) cleavage and bedding-cleavage intersections for the map area and structural data for folds (c) and movement surfaces (d) for bedding-parallel faults in the fault-related folds of the Musquodoboit Valley Fault.

The fold geometry of the Wittenburg synclinorium is similar to the fold geometry in the Rawdon Hills synclinorium (Horne, 1993,1995). The lack of folds on the steep limbs of the synclinorium (Cunard Member) suggests that the South Branch Stewiacke Anticline and unnamed synclines within the Glen Brook Member formed after regional folding of the slate belt, and probably reflect shortening within the hinge of the synclinorium.
(a) Benvie Brook

Kent Brook

(b) Model

Figure 5. (a) Cross-sections along Benvie Brook (Section Line A-B, Fig. 3) and Kent Brook (Section Line C-D, Fig. 3) showing the south-side-down folding of bedding and cleavage in the Musquodoboit Valley Fault. Sense of shear on bedding-parallel faults interpreted from related folds and crenulation cleavage (Fig. 6). (b) Model for the Musquodoboit Valley Fault (MVF), with north-side-up displacement resulting in a fault-related kink-style fold where bedding is rotated down toward the south. Cretaceous sediments (K) are deformed by similar fault-related folds but are unconformably overlain by Pleistocene till (P).

Discussion

This study has confirmed similarities between the Wittenburg Mountain and Rawdon Hills slate belts. The stratigraphy of the Wittenburg Mountain slate belt is similar to that in the Rawdon Hills slate belt, consisting of lower Cunard and overlying Glen Brook members (Fig. 3). Stratigraphy is reflected in the aeromagnetic data and, therefore, these data can be used to define the stratigraphy of the Wittenburg Mountain slate belt outside the mapped area (i.e. assumed contacts, Fig. 2).

The Wittenburg Mountain slate belt forms an elevated, fault-bounded plateau. The Musquodoboit
Valley Fault bounds the south margin and records slate-belt-up displacement (this study; Boehner, 1977). The north margin is bound by the Meadowvale Fault (Fig. 2) and also records slate-belt-up displacement (Giles and Boehm, 1982); thus, the slate belt is interpreted as a horst structure. Recent shallow seismic data indicate similar fault-related folds in the Cretaceous sediments located in the area adjacent to the Musquodoboit Valley Fault (Stea and Pullen, 1998), therefore constraining at least some post-Cretaceous displacement on the Musquodoboit Valley Fault. This is significant, as it suggests a young age for the formation of the Rawdon Hills and Wittenburg Mountain horst structures.

Bounding faults of the Wittenburg Mountain and Rawdon Hills horsts occur at or near the boundary of the Halifax and Goldenville formations and may reflect localization of strain between units of contrasting competency. However, the subsurface projection of the faults is unknown and the folding of bedding in the proposed model for the Musquodoboit Valley Fault (Fig. 5b) requires displacement to be oblique to bedding; if displacement was bedding-parallel then folding would not occur.

This study confirms the geological similarities of the Rawdon Hills and Wittenburg Mountain slate belts and thus demonstrates the application of aeromagnetic and digital elevation data for predicting the character of regional geological features when comparing areas with detailed information with less well known areas.

References


