

## Northern Half of NORTH GRANTHAM QUADRANGLE, NH

### Summary of Bedrock Geology by Peter J. Thompson

The mapped area lies between the Lebanon dome and Meriden antiform to the west, and the south-plunging Mascoma dome to the northeast. The western third of the quadrangle is underlain by Ordovician rocks of the Ammonoosuc Volcanics and Partridge Formation, which make up the Bronson Hill volcanic arc, here in the Cornish nappe. Bedding and foliation dip northwest toward the south end of the Lebanon dome, where it is overturned toward the south (Thompson, 2015). Prior to that dome-stage overturning the sequence had been inverted, with the older Ammonoosuc above Partridge.

The intensely folded rocks south of Mascoma Lake have puzzled geologists for years. A stratigraphic sequence of Ammonoosuc Volcanics, Clough Quartzite, Fitch Formation and Littleton Formation overlie Oliverian Gneiss of the Mascoma dome. The map pattern is the result of several interfering sets of folds: F<sub>1</sub> isoclines between the autochthon and the overlying Bethlehem Gneiss, a large overturned F<sub>2</sub> fold trending NE and plunging SE, and open upright cross folds that plunge south. A weaker set of approximately E-W cross folds can be seen in some outcrops, and locally kink folds with gently dipping axial planes also deform older fabrics. The kink folds are likely associated with the Grantham normal fault, which lies within 2 km east of the quadrangle.

Overall, bedding and S<sub>1</sub> foliation in the area south of Mascoma Lake dip towards the Bethlehem Gneiss, which occupies a sulcus between the south-plunging Mascoma dome and the north-plunging Croydon dome (see Lyons et al., 1997). Chapman (1939) mapped the interlayered quartzites, conglomerates and schists between the Ammonoosuc and the Bethlehem all as Clough Quartzite. Thompson (1988) reinterpreted the major schist layers as three F<sub>1</sub> infolds: from north to south, Littleton in a syncline and two anticlines of Partridge, separated by attenuated Clough Quartzite layers. The present mapping does not support the latter interpretation. Littleton, Fitch and Clough strike south and dip east all along the west side of the area, precluding a connection between Littleton and the lowermost Scs. The lower contact of the Fitch with the Clough curves around to the SE, passing through the vertical to dip south toward the overlying Bethlehem Gneiss. Numerous outcrops of schist and granofels (here interpreted as Fitch) occupy the area south of this contact, shown by Thompson (1988) as Partridge Formation. Although somewhat rusty, the rocks do not resemble Partridge, even at sillimanite grade. More field work is needed to confirm the continuation of Fitch-like rocks in the center of the dome-stage antiform, south of I-89. The Clough immediately below the Bethlehem occupies a large isoclinal anticline that closes westward. It is the same isocline as the long finger of Clough in the map pattern farther west.

The Ordovician rocks of the Cornish nappe are separated from Devonian Littleton Formation to the east by a thin quartzite, which is continuous with the so-called Hardy Hill Quartzite in the Enfield quadrangle, now correlated with Clough Quartzite (Lyons et al., 1997; Thompson, 2014). Open folds plunge NE, with a sinistral sense related either to the dome-stage Meriden antiform or the Northey Hill shear zone, or both (Thompson, 2016). An isoclinal fold in the Littleton metavolcanic member is also sinistral, but it plunges south. In cross-section view this fold can be seen to lie on the west limb of a major F<sub>1</sub> syncline within the Littleton. Map-scale F<sub>1</sub> folds in the Clough Quartzite above the autochthon, by contrast, are dextral, and lie on what was originally the upright limb of that syncline, which is cored by Littleton Formation and which opened westward. To see this properly in cross-section, one must mentally undo the large overturned F<sub>2</sub> dome-stage fold cored by Oliverian Gneiss. All the rocks from here west to Great Brook, in fact, were overturned during the dome stage of deformation. The major F<sub>1</sub>

syncline continues in quadrangles to the north as the Garnet Hill syncline (Thompson, 2016), where it is intruded by Bethlehem Gneiss in the Indian Pond pluton (Thompson, 2008). The overturned limb of this syncline reappears to the west, where Ordovician rocks lie above the Clough in the Cornish nappe. If this interpretation is correct, it implies two important conclusions: (1) the Bethlehem Gneiss cuts downward across the Skitchewaug nappe from its usual tectonic position above the Skitchewaug (i.e. Fall Mountain nappe/Brennan Hill thrust) into the underlying syncline, and (2) the Skitchewaug and Cornish nappes are one and the same. See Robinson et al. (1993) and Thompson et al. (1968) for details of the nappe theory in New Hampshire.

In the very NE corner of the quadrangle, north of Mascoma Lake, the Ammonoosuc/Oliverian contact is apparently repeated, which Chapman (1939) explained by extending a branch of the Grantham fault NW across the lake. More field work is needed to confirm these relationships.

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