1-1-1995

Reconnaissance geology in the Ellsworth area, July, 1995

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RECONAISSANCE GEOLOGY IN THE ELLSWORTH, MAINE, AREA JULY, 1995

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INTENT AND FOCUS OF WORK

This one week project was a pilot geological study directed at testing the feasibility of a future, larger scale geological mapping program in the Ellsworth, Maine, area. The Ellsworth area was chosen because 1) there are no standard 1:24,000 scale geological maps of the area, 2) the region is continuing to show an increase in development, and 3) previously unstudied geological relationships in the area are critical to understanding the regional geology of coastal Maine.

REGIONAL GEOLOGIC SETTING

The boundary separating two major lithotectonic belts of coastal Maine and southeastern New Brunswick, the Ellsworth belt to the southeast and the St. Croix belt to the northwest, trends through the Ellsworth area. This boundary, informally termed the Graham Lake-Rockland line (Osberg, et al., 1989), possibly represents the inland extension of the Turtle Head fault zone of Penobscot Bay In the Ellsworth area, this boundary is separated from the Turtle Head fault zone by the Early Devonian Lucerne pluton to the southwest and it is abruptly truncated to the northeast by the Early Devonian Deblois pluton.

To the southeast of the boundary, the Ellsworth belt (Berry and Osberg, 1989) is dominated by late Precambrian to Cambrian greenschist grade quartz-chlorite phyllites, psammites, and metavolcanics. In the study area, rocks of the belt have been assigned to the Ellsworth Formation (Smith et al., 1907). A recent, unpublished U-Pb zircon radiometric date on a felsic metavolcanic in the formation has yielded an age of approximately 500 Ma (R. Tucker, pers. comm. from C. Guidotti). In contrast, the St. Croix belt (e.g. Ludman, 1987) to the northwest is comprised of dominantly Cambrian-Ordovician black phyllites and quartzose metaclastic rocks (Berry and Osberg, 1989). Rocks of the St. Croix belt in the study area comprise the Penobscot Formation, which can be traced northeastwards into the fossiliferous Tremadocian Calais Formation near the international boundary (e.g. Berry and Osberg, 1989).

The contact between the Ellsworth and Penobscot belts has been interpreted as tectonic, with either strike slip (e.g. Stewart, 1974) or thrust motion (e.g. Osberg, et al. 1985) and has been hinted at possibly being stratigraphic (Berry and Osberg, 1989, p.

25). One of the major goals of this study is to clarify the nature of this boundary.

PROJECT LOGISTICS

Approximately six working days by the author and a graduate student from NCSU were spent in the Ellsworth area during late July, 1995, with the effort partitioned as follows:

- one day of regional geological reconaissance with Doug Reusch, local graduate student/geologist at the University of Maine, Orono, who is familiar with some of the rocks in the area.
- approximately three days of roadside geology, traversing, and canoe work devoted to investigating the nature of the Ellsworth-Penobscot boundary.
- two days of coastal, river, and roadside geology investigating the structural/lithologic character of the Ellsworth Formation.

This effort resulted in new lithologic and structural data concerning the Ellsworth belt and its relationship to the Penobscot belt.

SIGNIFICANT OBSERVATIONS AND PRELIMINARY INTERPRETATIONS

The most significant new observations of this study relate to the boundary between the two major belts and to the structural history of the Ellsworth belt.

Observations on the Ellsworth-Penobscot boundary: The boundary is abrupt in at least two localities on the east and southeast side of Graham Lake, and can be located to within a quarter mile interval between outcrops of Penobscot and Ellsworth formations. In general, rocks of both the Ellsworth and Penobscot formations near the boundary are overprinted by a steep intense foliation that is stronger than elsewhere in either unit. There appear to be multiple foliations in each unit near the boundary with minor structures in one outcrop of Penobscot Formation on Graham Lake suggesting left lateral strike slip motion. A steeply plunging, fine-grained lineation was observed in both units near the boundary, and locally, it appears that cordierite porphyroblasts in the Penobscot Formation are aligned down the steep dip of the foliation near the contact. At one inland locality, a sliver of mildly deformed fragmental felsic volcanics, very similar to those of the Silurian-Devonian Castine Formation on Little Deer Isle, intervenes between the Ellsworth and Penobscot Formations.

Interpretation: These structural observations strongly suggest that the boundary between the two lithotectonic belts in the area is a fault. The apparent sliver of Castine volcanics along the fault is a potentially significant link between this fault and the Turtle Head fault zone. Castine volcanics lie against the south side of the Turtle Head fault zone on the east side of Penobscot Bay, to the southwest of the present study area. In addition, the sliver of Castine Formation along the fault may have been plucked from the Castine Formation to the southwest, indicating that the fault records at least a component of strike slip motion. The steep lineation observed in the area of the fault may relate to motion along the fault, and is compatible with Osberg's interpretation that the contact is a thrust fault (Osberg et al., 1995). However, in many places, the lineation may be an intersection lineation; also the observation of aligned cordierite porphyroblasts in the Penobscot Formation hints that the lineation may be related to emplacement of the nearby Lucerne pluton, with the cordierite potentially representing syn-emplacement dynamothermal metamorphism. The overall fine-grained nature of rocks in the vicinity of the contact preclude definite interpretation of shear sense in the field; interpretation of these fabrics awaits further field investigation and microstructural study.

Observations on the structural history of the Ellsworth belt: Rocks of the Ellsworth belt display multiple phases of deformation. The most prominent structure in the belt is a strong, layer-parallel foliation, termed the main foliation, that locally transposes layering and an earlier foliation; thus, the main foliation is composite. The nature of the earlier foliation is uncertain. South of the town of Ellsworth, layering and the main foliation are generally moderately- to shallowly-dipping, whereas to the north of the community, these features are generally moderately- to steeply-dipping. The main foliation is commonly accompanied by a northwest-southeast trending mineral lineation and in many places the foliation displays asymmetric structures, such as minor intrafolial folds, S-C fabrics, and shear bands that indicate a tops to the northwest sense of shear along the foliation. The main foliation is overprinted by an inhomogeneously distributed late phase fold deformation with minor to map scale open to tight folds trending northeast to east with variable plunges on upright axial surfaces. Locally, a late phase foliation is developed axial planar to, and transposing these folds. The late folds appear to increase in amplitude and intensity northwards towards the Ellsworth-Penobscot contact and appear to be responsible for the increase in the dip of layering and the main foliation towards the north. Also to the north of Ellsworth community, there appears to be a preponderence of asymmetric late folds with a 'Z' sense of asymmetry where viewed along their axes towards the east. At Lamoine State Park, the northeast-trending late folds are accompanied by an apparently conjugate, northwest-trending set of folds and a third, east-west trending set of late folds. The interrelationships of these two fold sets was not observed.

Interpretation: The Ellsworth belt has been subjected to at least two phases of deformation; on the basis of the observations above, the main phase involved northwest directed thrusting of the Ellsworth Formation, whereas the later phase appears to be spatially related to the Ellsworth-Penobscot fault contact. If this observation is true, the orientation of the late folds with respect to the fault would indicate approximately north-south directed shortening and a sinistral sense of motion along the fault. Regional scale north-south shortening in the northern Appalachians has been considered to be the kinematic pattern of the Silurian to earliest Devonian early Acadian deformaton (Hibbard, 1994); if the late folding in the Ellsworth area is a manifestation of the early Acadian event, the main phase deformation of the Ellsworth belt, involving northwest directed thrusting, must be an older, Ordovician (?) event. These interpretations are tentative and their confirmation or negation requires futher study.

RECOMMENDATIONS

Results of this pilot study clearly indicate that a more ambitious field geological mapping project in the Ellsworth area is justified. Although exposure of bedrock is not as good as in nearby coastal areas, a study involving the judicious combination of field work and microstructural studies has the potential to lead to a significant new geological understanding of coastal Maine geology; particularly so if it is combined with a modest isotopic age dating program.

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