Three-Dimensional Geometry and Sequence of Faulting in the Feura Bush Quarry Duplex in Selkirk, New York

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Abstract

The Hudson Valley fold-thrust belt (HVB) is a north-south trending, 2 to 4 km-wide belt between Kingston and Albany, NY involving deformed Silurian through Devonian strata. Outcrops along the Helderberg Escarpment, a 20 to 50m high cliff representing the eastern boundary of the HVB, expose segments of the geometry of the HVB. One such exposure at the Feura Bush quarry near Selkirk, NY provides an excellent opportunity to study the three-dimensional geometry of the northern HVB. Our analysis indicates deformation in the quarry is accommodated along at least three detachments in the duplex. The folded nature of the two exposed detachments indicate the presence of an unexposed lower third detachment. The middle detachment separates intensely deformed rock below it from less intensely deformed rocks above. Between the lower and middle detachments, two sets of thrust faults intersect which we interpret as two faulting events as a result of progressive deformation. The presence of a deeper invisible detachment below the talus lining in the quarry floor. Intense deformation at the bottom of the quarry suggests the notion of progressive deformation, where the lower beds have accommodated higher strain than those at the top. The detachment horizons act as layers decoupling strain across units above and below the detachment horizons. The thinning of the thrust sheet towards the west is visible in the western wall, where the upper detachment terminates against the middle detachment. Minimum strain along the upper detachment is calculated to be around -5%, where the negative sign indicates compressional strain. Further work is necessary to completely evaluate the kinematics and the three-dimensional geometry of the structures in the Feura Bush quarry.

Introduction

Clastic and carbonate Siluro-Devonian strata exposed along the western bank of the Hudson River between Albany and Kingston, NY represent deformed rocks of the Hudson Valley Fold-Thrust Belt (HVB) formed during the Atdabanian (~390 Ma to ~370 Ma) (Fig. 1a). A fold-thrust belt refers to a linear band of deformed rocks along faults representing the three-dimensional geometry of structures exposed along the Helderberg Escarpment (such as Thacher Park in the HVB) varies along-strike of the structural grain. Outcrops along the Helderberg Escarpment, a 20 to 50m high cliff representing the eastern boundary of the HVB, expose segments of the geometry of the HVB. One such exposure at the Feura Bush quarry near Selkirk, NY provides an excellent opportunity to study the three-dimensional geometry of the northern HVB in context of the three-dimensional geometry of the southern and central HVB.

Discussion

Analysis of the walls of Feura Bush quarry indicates the presence of several faults and fault-related folds (Figs. 4 and 5). The northern wall exposes three shallowly dipping detachments (upper, middle, and lower) (Fig. 5) and steeply easterly dipping thrust ramps (Fig. 6). The middle detachment separates intensely deformed rock below the detachment from weakly deformed rocks above the detachment. The middle detachment represents an intensity change in the strain between the base and the top of the northern wall. The minimum strain accommodated along the upper detachment in the northern wall was calculated to be ~5% using a change of length over original length ratio technique (Fig. 7). Calculation of strain in the intensely deformed lower part of the northern wall is in progress. Cross-cutting relationships between ramps and the middle detachment in the northern wall indicate the presence of at least two sets of faults. Fig. 6 shows the truncation of fault set 1 against fault set 2. The two sets of faults can be either a result of two separate events of faulting or a result of progressive deformation where fault set 2 initiated due to the locking of fault slip along fault set 1. The geometric relationship between individual faults and fault-related folds represents an overall intensely deformed duplex structure (Fig. 6) between the lower and middle detachments.

The western exposure exposes two shallowly-dipping detachments which we interpret as the lower and middle detachments (Figs. 4 and 5). The upper detachment is exposed in the northern end of the western wall (Figs. 4 and 5). The thickness of rocks between the upper and the middle detachment in the western wall appear to rapidly decrease compared to the thickness of the rocks between the upper and middle detachment in the northern wall (Figs. 4 and 5). One interpretation of this geometry is that the upper detachment is terminating against the middle detachment due to reduction of slip along the middle detachment. Further analysis is being carried out to completely understand the geometry of the structures exposed along the western wall of the quarry.

The southern wall of the quarry exposes three shallowly dipping detachment horizons. Preliminary studies indicate an occurrence of an intensely deformed duplex between the middle and the lower detachment as observed in the northern wall. However, analysis of the structures in the southern wall is still in progress.

A three-dimensional rendering of the structure exposed in the quarry based on our observations along the quarry walls is presented in Fig. 4.

Conclusions

The structures present at the exposed section of the Hudson Valley Fold-Thrust Belt in the Feura Bush quarry are the result of movement along three detachments. The three detachments and their associated faults are the result of a west verging deformation. The folded nature of the exposed detachments indicates the presence of a deeper invisible detachment below the talus lining in the quarry floor. Intense deformation at the bottom of the quarry suggests the notion of progressive deformation, where the lower beds have accommodated higher strain than those at the top. The detachment horizons act as layers decoupling strain across units above and below the detachment horizons. The thinning of the thrust sheet towards the west is visible in the western wall, where the upper detachment terminates against the middle detachment. Minimum strain along the upper detachment is calculated to be around -5%, where the negative sign indicates compressional strain. Further work is necessary to completely evaluate the kinematics and the three-dimensional geometry of the structures in the Feura Bush quarry.

References


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