Unravelling the Structural Evolution and Regional Tectonic Importance of the Honey Hill Fault Zone, SE, Connecticut

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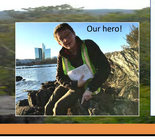
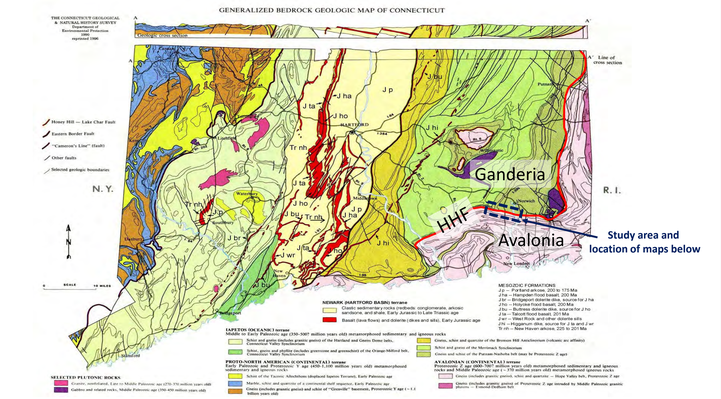
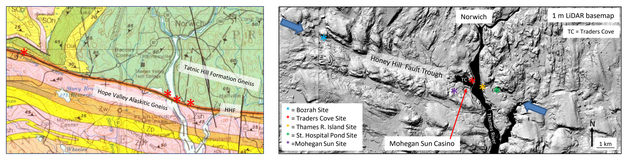


1. Abstract

The Honey Hill Fault system (HHF) is one of the most significant fault systems in southern New England because it forms a boundary between two major crustal domains (called `Avalonia' and `Ganderia'). It also links with the Lake Char Fault further north which has experienced repeated low-level historical seismicity, including a notable earthquake swarm in Plainfield in 2015. The fault system is poorly understood in terms of its motion history and timing. However, understanding the structural evolution of the HHF is essential for determining: 1) how the crust of southern New England was assembled, 2) how the Appalachian Mountains were created, and 3) how the mountain belt was later disassembled by orogenic collapse. All models of the tectonic evolution of southern New England have remained incomplete until now, because of uncertainty regarding the HHF system's history. In this study, detailed field investigations of the HHF between Bozrah and Norwich, CT were carried out during summer-fall, 2019 to document the rock types that the fault passes through and separates, structural evidence for brittle and ductile deformation, and kinematic indicators. In addition, samples were collected for thin-section analysis of micro-structures that reveal mineral-scale deformation mechanisms and shear sense. Our results indicate that the fault zone cuts through rocks that experienced two phases of top-to-the-S directed contractional deformation (D1/D2). Overprinting the older contractional structures are spectacular mylonites and ultramylonites that reveal high-temperature ductile shearing indicative of top-to-the-NW sinistral transtensional displacement (D3). Ductile D3 transtension was followed progressively by brittle top-to-the-NW transtensional and E-W sinistral faulting that cuts across earlier structures (D4). The full range of ductile-brittle kinematic indicators are preserved in the mylonitic gneisses. Late-stage retrogressed pseudotachylite is also present. Our results provide further evidence that the HHF was a regionally significant tectonic boundary that accommodated deep-seated orogenic collapse in the southeastern New England Appalachians following Pennsylvanian-Permian Pangea assembly.



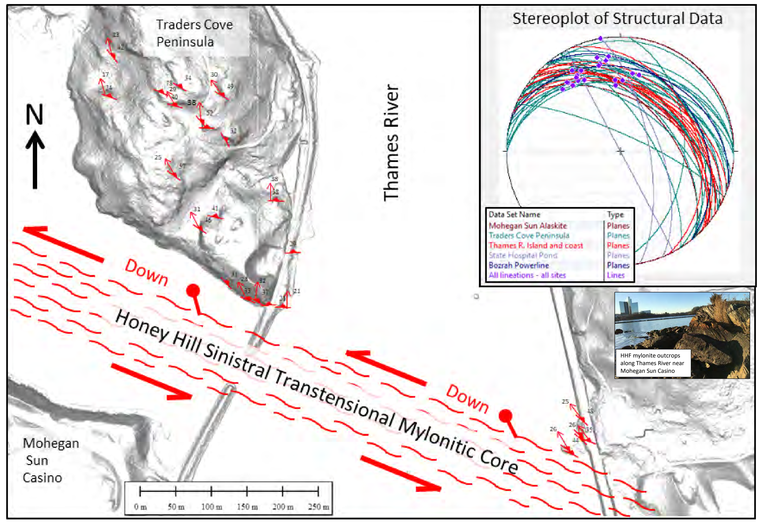


* = Field study areas

HHF = Honey Hill Fault Zone

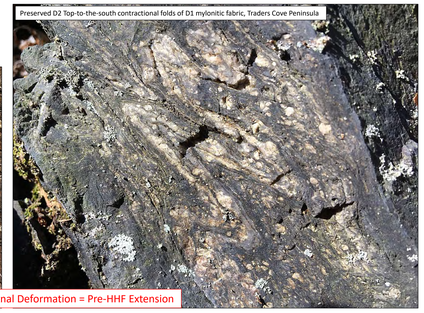
2. Location Map and Geological Setting

3. Structural Map and Data

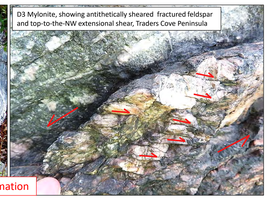


4. Field Photos

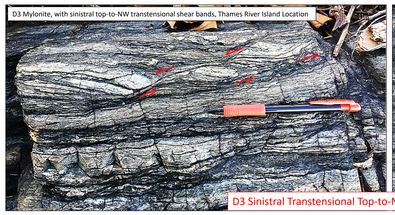
Key structural evidence for different deformation events

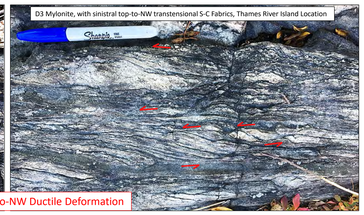


D1/D2 Contractional Deformation = Pre-HHF Extension

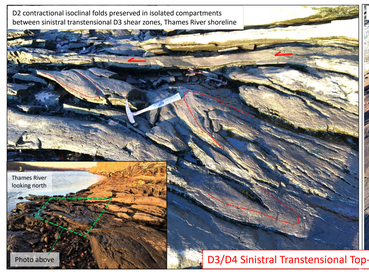


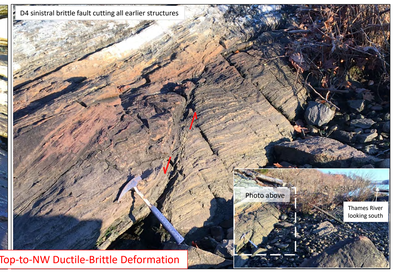
D3 Sinistral Transtensional Top-to-NW Ductile Deformation





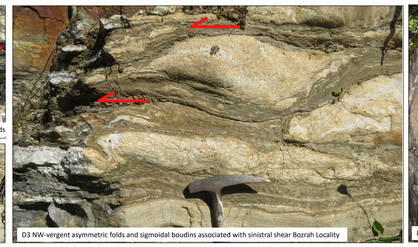
D3 Sinistral Transtensional Top-to-NW Ductile Deformation

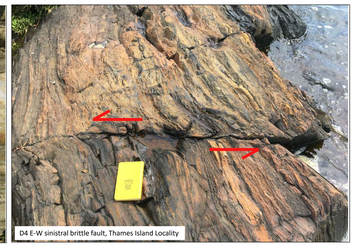




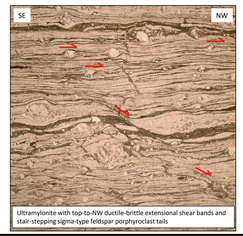
D3/D4 Sinistral Transtensional Top-to-NW Ductile-Brittle Deformation

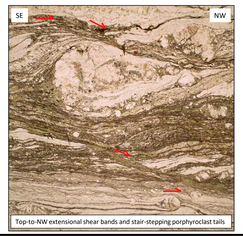
5. D3/D4 Brittle-ductile sinistral transtension – field photos

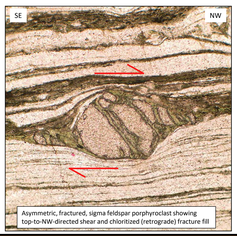


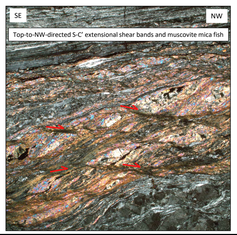


6. Thin Sections from Trader Cove Peninsula Mylonite

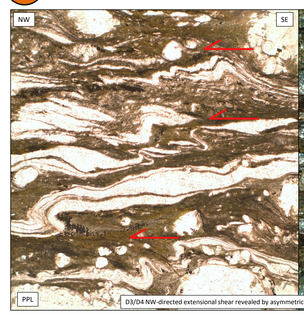


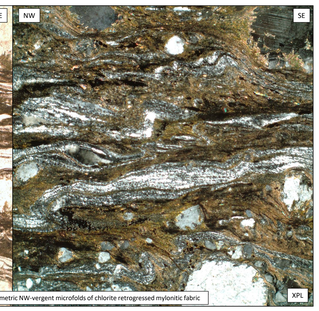


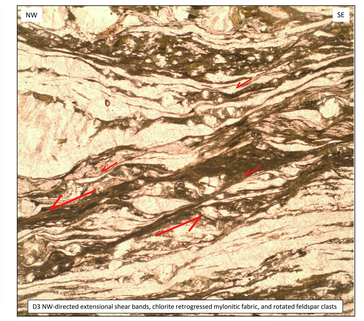


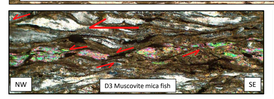


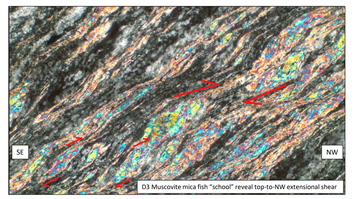
7. Thin Sections from Thames River Shoreline and Island Outcrops











8. Conclusions

1) **Four phases of deformation are recognized in the high-grade gneisses that are deformed by the Honey Hill Fault System.**
2) **D1/D2 contractional structures include metamorphic foliation that is tight to isoclinally folded with top-to-south vergence**
3) **D3 is a major top-to-the-NW extensional shearing event that is expressed by mylonites and ultramylonites that strike NW-SE with N-NW plunging stretching lineations. D3 structures heavily overprint D1/D2 structures.**
4) **World-class and unambiguous kinematic indicators reveal high temperature-to-later low-temperature top-to–the-NW extensional and sinistral transtensional shear in the HHF zone.**
5) **D4 represents a brittle continuation of D2 extensional/transtensional sinistral shear during exhumation under cooler upper crustal conditions, but with similar kinematics. Brittle cataclastic and pseudotachylite-bearing faults cut all older structures.**
6) **This is the first study to reveal the truly spectacular deformational history of the HHF – one of the most important, long-lived, tectonic boundaries in southern New England.**

Key references

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