POLYMETAMORPHISM IN THE CAVENDISH OUTLIER, CHESTER DOME, VERMONT

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Much evidence in and around the Chester and Athens Domes of southeastern Vermont points toward a polymetamorphic history of that area. These domes were most likely influenced by two major Paleozoic metamorphisms: the Ordovician Taconian Orogeny and the Devonian Acadian Orogeny (Rosenfeld, 1968). The Taconian Orogeny is known to have affected western Vermont and resulted primarily in westward thrusting of Late Proterozoic to Ordovician eastern deep-sea sediments over the coeval shelf-sediments of western New England and New York (Stanley and Ratcliffe, 1985). Evidence for this orogeny in southeastern Vermont is sparse; the first suggestion of its occurrence there was not until Rosenfeld (1968) postulated Ordovician ages for garnet cores in high-aluminous pelitic schists on the western flanks of the Athens Dome. The Acadian Orogeny produced large-scale recumbent folding in southeastern Vermont, overprinting much of the evidence for Taconian metamorphism in that area. The latest phase of Acadian deformation was marked by the upsurgence of Precambrian basement-cored gneiss domes, including the Chester and Athens Domes (Rosenfeld, 1968).

Garnet studies have played a large role in unravelling the metamorphic history of the Chester Dome area. Rosenfeld (1968) noted distinct textural unconformities in garnets of the Cambrian Pinney Hollow Formation along the west flank of the Athens Dome and suggested two periods of garnet growth, separated by a hiatus. Since he did not observe textural unconformities in rocks of Silurian to Devonian age, Rosenfeld concluded that the cores of these garnets grew during Taconian metamorphism, whereas the garnet rims (i.e. the area outside the textural unconformity) grew during later, Acadian metamorphism. Karabinos (1985) noted textural unconformities in garnets near Jamaica, Vermont, six miles west of Rosenfeld's Athens Dome locality. Based on inclusion textures and zoning patterns within the garnets, Karabinos (1985) interpreted these textural unconformities as signifying two stages of garnet growth, separated by a period of retrograde garnet consumption. He believed the retrogression to be the result of synmetamorphic Taconian thrusting of garnet-bearing rocks. Cook and Karabinos (1988) have documented the occurrence of the textural unconformity in garnets in rocks of various bulk compositions throughout southeastern Vermont. Based on this and other evidence, Cook and Karabinos (1988) have questioned a suggestion by Thompson et al. (1977) that the textural unconformity need not represent a period of retrogression, but rather a garnet-consuming reaction within a prograde metamorphic sequence.

Several authors have attempted to assign absolute ages to the various metamorphic events experienced in western New England. Laird et al. (1984) and Sutter et al. (1985) concluded, based on $^{40}Ar/^{39}Ar$ ages from amphibole and muscovite in Proterozoic to Ordovician mafic schists of northern Vermont and biotites and hornblendes from the Proterozoic Y-gneisses of the Berkshire and Green Mountain Anticlinoria, respectively, that the thermal peak of recrystallization in western New England occurred between ~470-440 m.y. (Taconian). To explain K-Ar and $^{40}Ar/^{39}Ar$ dates of ~370 m.y. in muscovite, amphibole, and biotite of the pre-Silurian cover rock east of the Green Mountain Anticlinorium, both works invoked kyanite-grade Acadian overprinting in southeastern Vermont.

Within the Middle Proterozoic core of the Chester Dome exists an outlier of Late Proterozoic to Cambrian lithologies, referred to here as the Cavendish outlier. This outlier was produced by the late Acadian doming of an early Acadian nappe. The cover rocks of the outlier occupy the cores of two antiformal synclines, whereas the Precambrian basement in the northwest corner is the core of a synformal anticline. Doll et al., (1961) labelled the rocks in this outlier as Cavendish Formation, consisting of a marble unit and a pelitic schist (Readsboro Member). Later Thompson et al., (1977) correlated the marble unit with the dolomite of the Late Proterozoic to Cambrian Tyson Formation, which rests unconformably on the the Middle Proterozoic core of the Dome (Mt. Holly Complex), and the Readsboro Member with the Late Proterozoic to Cambrian Hoosac Formation. This study further subdivides the Hoosac Formation of the outlier into three lithologies (Fig's. 1, 2). Rimming the Tyson/Hoosac contact is a unit of q(uar)tz-mus(covite)-chl(orite)-bio(tite)-alb(ite) schist. The bulk of the remainder of the Cavendish outlier is pelitic schist defined by the AFM assemblage gar(net)-bio-chl in a matrix of qtz+mus±alb±tourmaline. Finally, a thin band of sta(urolite)-gar-bio-chl±kya(nite) runs atop the NE-SW oriented central ridge of the outlier.

The variation of AFM assemblages within the pelitic schists of the Hoosac Formation in the Cavendish outlier can be more easily explained by structural and bulk-compositional data than by changes in metamorphic grade. In areas investigated by the author on the flanks of the Chester and Athens Domes, the Hoosac Formation consists of a basal member of qtz-mus-chl-alb schist beneath schist with the assemblage gar-bio-chl±alb. The latter is overlain by sta-gar-bio-chl±kya schist. Allowing for early Acadian nappe emplacement and late-Acadian doming, this is the lithologic pattern of the outlier. Coupled with the close interlayering of the three Hoosac lithologies along the central ridge of the outlier and the works of Thompson and Norton (1968) and Cook and Karabinos (1988) which postulate the Chester and Athens Domes to have undergone kyanite-grade metamorphism during the metamorphic peak of the Acadian orogeny, this interpretation argues against the presence of an isograd in the Cavendish outlier.

Inclusions and textural patterns within garnets of the Cavendish outlier suggest that garnets there grew in two separate stages. Most garnets display inclusion-rich cores (G1) and inclusion-poor to inclusion-free rims (G2). The inclusion trails in the G1 portions of the garnets are straight to gently sigmoidal and at a high angle to the matrix cleavage (S2), suggesting that the garnet cores overgrew an early schistocity (S1) (Fig's 3, 4). Cook and Karabinos (1988) have noted similar patterns throughout southeastern Vermont and tentatively suggested the S1 fabric is Taconian. Staurolite and kyanite grains are partially enveloped within the G2 rims of several garnets in the sta-gar-bio±kya schists of the Hoosac Formation in the outlier. As certain of these kyanite and staurolite crystals overgrow the matrix cleavage (S2), garnet growth clearly occurred after the development of the S2 fabric (Fig. 5).

Chlorite textures in the matrix of the pelitic schists suggest that the garnets of the outlier experienced a prograde-retrograde-prograde-retrograde history. Many garnets, especially in matrices defined by the assemblage gar-chl-bio±alb show heavy chlorite retrogression and dissection (Fig. 6) This chlorite reacted with the G2 portion of the garnet and overgrew the S2 crenulation cleavage. Thus it is clear that a period of retrogression beset the garnets in the outlier following the development of S2 cleavage. Moreover, in the matrix of some rocks of gar-chl-bio±alb bulk composition, clots of randomly oriented chlorite grains are deformed by S2 (Fig. 5). Such chlorite clots suggest a retrogressive period between the end of garnet growth over the S1 fabric and before the development of the S2 cleavage. Coupled with the textural and mineralogical evidence presented above, this evidence for retrogression suggests a prograde-retrograde-prograde-retrograde sequence of metamorphism. These findings are consistent with the petrologic and chemical data presented by Karabinos (1985) and Cook and Karabinos (1988).

The majority of the AFM topologies noted within the high-aluminous pelitic schists of the Cavendish outlier (chl-bio, sta-gar-chl-bio, and kya-sta-gar-chl-bio), including those defined by inclusions in garnets (ctd-gar-chl, sta-ctd-gar-chl, and sta-gar-chl), can be explained using AFM space as presented by Thompson (1957). Beginning with the two-phase assemblage chl-ctd, these assemblages grew by the discontinuous reaction chl + ctd + qtz --> gar + water (1) to form the assemblage ctd-gar-chl. Further prograde metamorphism resulted in staurolite growth by the discontinuous reaction ctd + qtz --> chl + gar + sta + water (2), which produced the assemblage sta-ctd-gar-chl with garnet most likely stabilized by manganese. Full progression of this reaction produced the assemblage sta-gar-chl, reaction (2) being terminal to ctd in AFM space. This reaction represents the highest metamorphic grade achieved by the early (Taconian) metamorphism within the outlier, as defined by garnet inclusions. Acadian metamorphism progressed further, such that within high-aluminous pelitic schists the gar-chl tieline broke to produce staurolite by the discontinuous reaction chl + gar + mus --> sta + bio (3), again with garnet stabilized by manganese. Finally, with Acadian metamorphic peak at temperatures of ~600°C and pressures of 5-6kb (Thompson et al. (1977)) the discontinuous reaction sta + chl + mus --> bio + kya (4) produced the five-phase assemblage kya-sta-gar-chl-bio with garnet stabilized by manganese and staurolite by zinc.

The assemblage gar-chl-bio, which defines the majority of the pelitic schist of the outlier, should not exist at kyanite-grade metamorphism according to Thompson's AFM space. The gar-chl tieline should have broken to produce staurolite and biotite. Yet while this model seems to work for rocks of high-aluminous bulk compositions, rocks with lower aluminum contents do not follow the pattern. The reason for the absence of staurolite in these rocks is unclear from the data in this paper.

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Fig. 1: Generalized Lithologic Map of the Cavendish Outlier

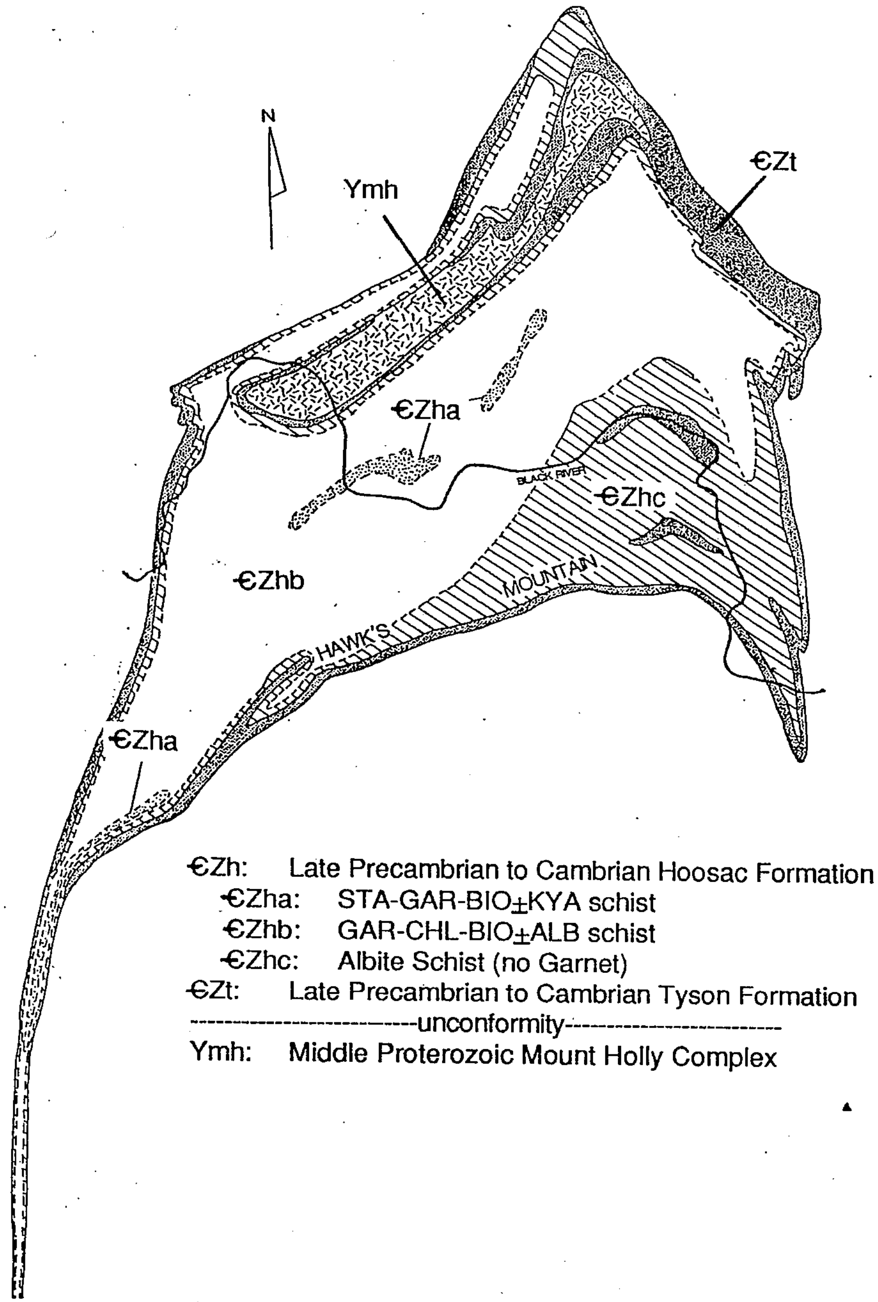
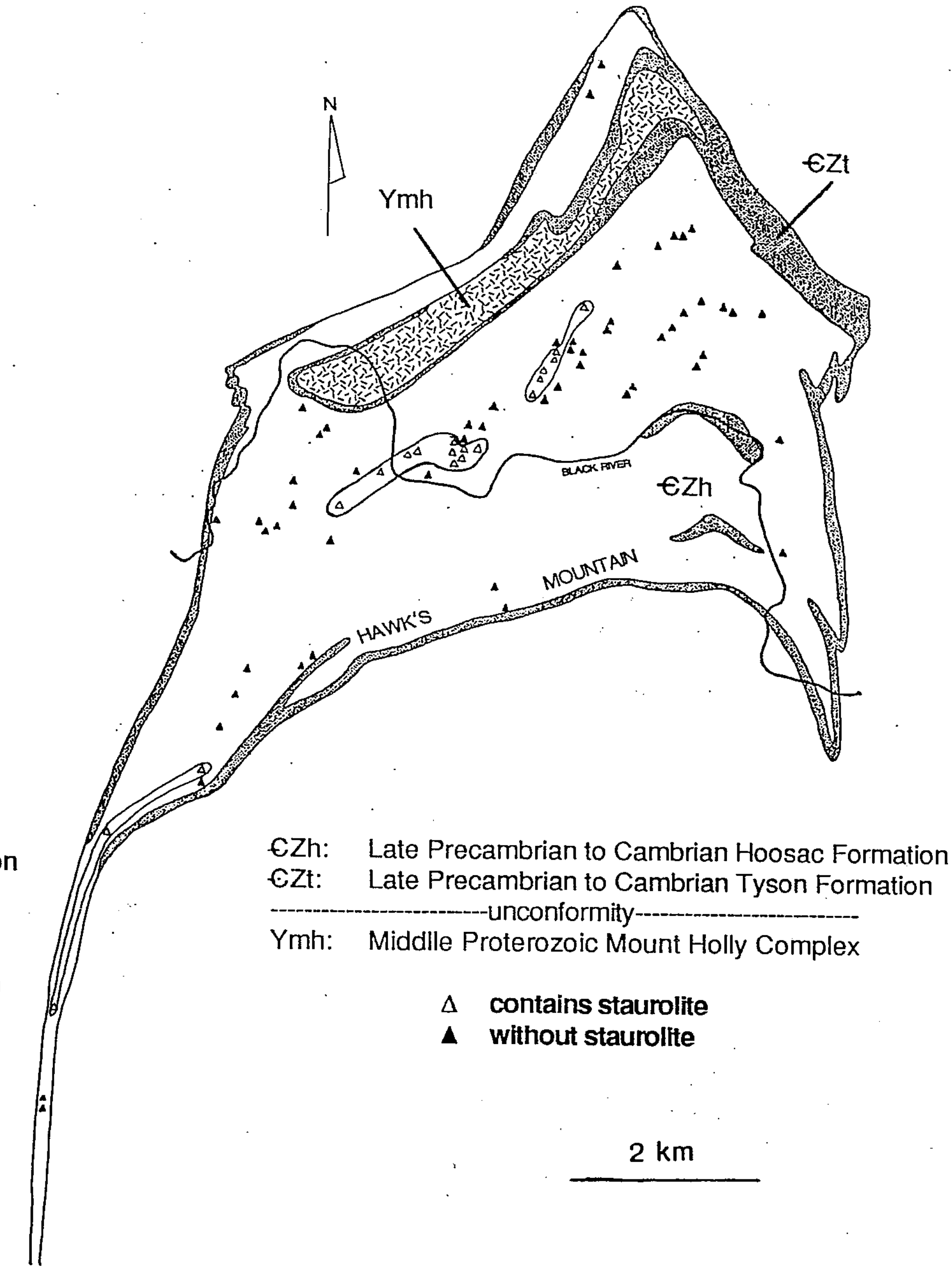


Fig. 2: Samples Containing Staurolite in Matrix



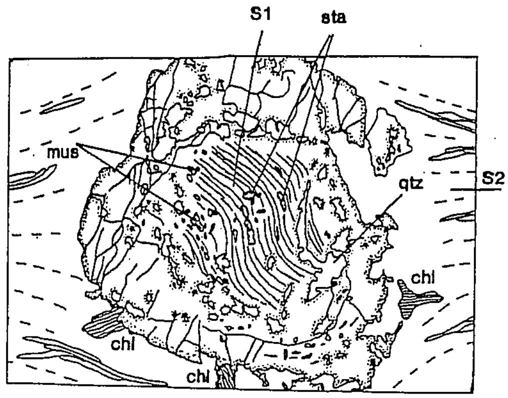


Fig. 3:
Sketch Showing First-Stage Garnet Inclusion Trails (S1) Truncated by Second-Stage Garnet

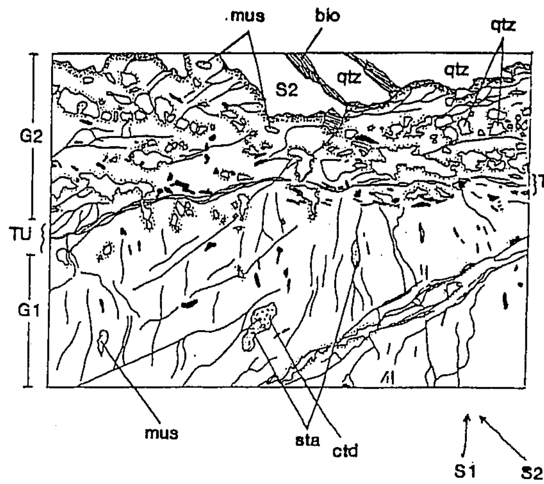


Fig. 4: Sketch of Sample S11 Showing Textural Unconformity

1mm

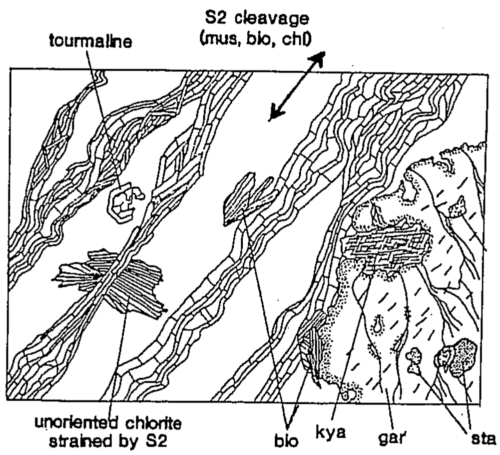


Fig. 5:
Sketch Showing Late Kyanite Enveloped by Second-Stage Garnet : Randomly Oriented Chlorite Grain Deformed by Matrix Cleavage (Based on Samples S42B and S60)

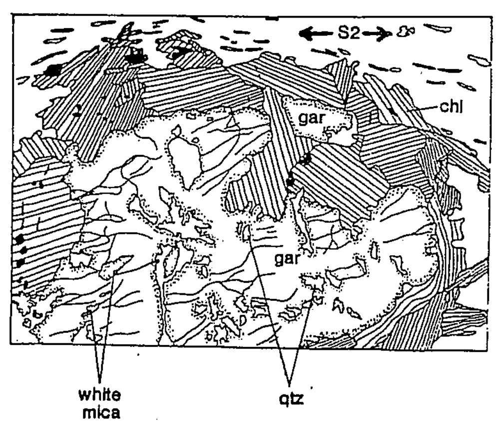


Fig. 6:
Sketch Showing Chlorite Rimming Garnet (sample S33)