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Trip F-4

GEOLOGIC SETTING OF THE HARVARD CONGLOMERATE, HARVARD, MASSACHUSETTS

by

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"In Harvard and Bolton, east of the granite range and closely connected with the slates just described, beds of conglomerate occur, interstratified with argillite, which here coincides in strike and dip with the mica slates. (Strike, N.65° to 70°E. Dip, 45° to 80° N.W.) This conglomerate is very interesting from its relations to the surrounding rocks, and the remarkable changes that portions of it have undergone. It appears in a range extending from Pin Hill, in Harvard, to the summit of Wattoquotoc in the south-west part of Bolton, forming several high hills that are marked features of the landscape. The series of specimens that I have placed in the Cabinet of the Society shows that the pebbles have, in many cases, been flattened, bent, and even drawn out into layers, giving an agate-like structure to some of the rock. ..... The principal conglomerate beds lie between hills of porphyritic granite on the west and north, and mica slate and gneiss on the south-east, yet not a pebble of granite or gneiss, so far as I have seen, enters into its composition, and the slaty pebbles that occur, appear to belong to argillite rather than mica slate. Some ten miles to the south-west, however, are extensive beds of slate, interstratified with a quartzite closely resembling the pebbles that form the mass of the conglomerate. ....

"The rock which immediately encloses the beds of slate and conglomerate at Harvard is of a very peculiar character, as shown by specimens that I have placed in the Society's Collection. It appears in unstratified masses, resembling granite, but mixed with fragments of slate, and destitute of mica; and also as a schistose feldspathic gneiss in which slaty particles take the place of mica; while the feldspar is in perfect rounded crystals, giving a porphyritic aspect to the rock." - L. S. Burbank, 1876a, pp. 45-46.

Pin Hill in Harvard, Massachusetts, in the southern part of Ayer 7 1/2 minute topographic quadrangle, is a resistant northeast trending strike ridge held up by interbedded polymict conglomerate and phyllite of the Harvard Conglomerate, first so designated a century ago by L. S. Burbank (1876, 1876a; also see Crosby, 1876, and Emerson, 1917). Northwest of the conglomerate there is a large outcrop area of Ayer Granite, and the contact is well exposed in a cut on the northeast side of Depot Street. In outcrops 700 feet northwest of the contact the granite is the typical porphyritic variety of Ayer Granite with carlsbad-twinned potassic feldspar megacrysts up to about 6 cm long, thus closely resembling some varieties of the Kinsman Quartz Monzonite of the New Hampshire Magma Series in New Hampshire (Billings, 1956). Conspicuous in the slightly altered matrix are slightly bluish quartz grains about 1 cm across, and small flakes of biotite. In outcrops twenty feet west of the contact the feldspar is sericitized and fragmented, and large megacrysts are inconspicuous. In thin section quartz and feldspar show abundant strain effects and the matrix consists of fine mortar texture quartz and feldspar with abundant sericite and subsidiary chlorite. Feldspar becomes increasingly scarce closer to the contact and, within one or two feet of it, the "granite" consists essentially of quartz and white mica. The conglomerate immediately east of the contact contains quartzite cobbles up to 15 cm in largest dimension.

Hansen (1956) regarded the Ayer Granite as younger than the Harvard Conglomerate and intrusive into it, but commented on the absence of obvious contact metamorphic effects. The development of chloritoid in the matrix of the conglomerate and in the interbedded phyllites was attributed by him to metasomatism related to the origin of the "Unnamed Gneiss at Bare Hill Pond", bordering the Harvard Conglomerate on the east.

On numerous Harvard University field trips in the late 1950's and early 60's Thompson became convinced that the contact relations might be explained by an unconformity, with chemical weathering of the granite before deposition of the conglomerate, amd recrystallization, shearing, and hydration of the granite during the metamorphism and folding of the conglomerate,

On a field trip in the spring of 1964, Robinson and some students from the University of Massachusetts decided on the spur of the moment to seek further evidence for or against the unconformity hypothesis by tracing the contact northeast from the road cut along the northwest slope of the hill. The result was the discovery of the small exposure illustrated in Figure 1, about 500 feet northeast of the road cut. Figure 1 is a drawing from a photograph and the view is of a vertical surface that faces southwest.

The contact (Fig. 1) is a clear-cut unconformity. The aplitic dikes in the granite (now quartz-sericite schist) are truncated by the base of the Harvard Conglomerate and there appear to be clasts of the aplitic material in the conglomerate. The weathered granite was apparently less resistant to erosion than the aplitic rock so that the dike stood out as a ridge on the erosion surface. The absence of granite clasts also testifies to the weathered character of the granite. During subsequent deformation a strong, probably axial-plane, foliation was superimposed on the conglomerate and granite, and the dikes were apparently rotated into parallelism with the foliation if they were not already in that orientation.

Interbedded with the conglomerate and overlying it are gray, green and faintly purple phyllites. The phyllites and the matrix of the conglomerate contain quartz, chloritoid (abundant), near isotropic chlorite and white mica. Peter Bell (personal communication, early 1960's) reported the presence of paragonite and pyrophyllite in addition to muscovite in some specimens. X-ray diffraction study by E.A. Perry, Jr. (personal communication, 1976) of one specimen each of phyllite and of conglomerate showed only muscovite and, in addition, minor albite. The purplish layers and conglomerates contain finely divided hematite, the gray layers may contain carbonaceous material. The mineral assemblages in the phyllites and conglomerate matrix are characteristic of the low-grade regional metamorphism of a highly aluminous pelite and require no special metasomatic effects. Emerson (1917) suggested that the Harvard Conglomerate might be a tillite, but the

FIGURE 1.

highly aluminous nature of the matrix and the phyllites is difficult to explain in this interpretation. To us the preserved sedimentological features are characteristic of many basal conglomerates in New England (such as parts of the Clough Quartzite) and elsewhere.

The deformation history of the conglomerate itself is best illustrated in a small exposure at the high point of Depot Street (north side). Here the conglomerate pebbles show severe flattening and elongation in the plane of an early foliation. This pebble foliation and lineation was then deformed by tight folds overturned to the east, with development of a prominent west-dipping axial plane foliation. Some thin sections of the phyllite show a fine early mica foliation cut, in some cases at right angles, by a strongly developed slip cleavage. At the unconformity illustrated in Figure 1 the predominant foliation and the only one shown in the Figure is the early one. However, in the right lighting a slip cleavage may also be discerned that dips 10-15° more steeply.

The eastern contact of the Harvard Conglomerate sequence is exposed on the south side of Depot Street at the east end of the cut, and appears to be a post-metamorphic fault, perhaps Permian or even Triassic in age (see Castle et al., 1975 for a general discussion of faulting in this part of Massachusetts). The rocks east of this fault are part of the "Unnamed Gneiss at Bare Hill Pond" of Hansen (1956), and were regarded by him as of largely metasomatic origin (the "Green Eyrie Migmatite", see also Currier and Jahns, 1952). Castle et al. (1975), on the other hand, regarded these rocks as mylonitized Ayer Granite. To us some exposures of these gneisses, and of the rocks that border them on the east, the Vaughan Hills Member of the Worcester Formation of Hansen (1956), closely resemble rocks that are demonstrably metamorphosed volcanics elsewhere. This matter clearly needs further study.

We regard the Harvard Conglomerate and its associated phyllites as correlative with the basal units of the fossiliferous Pennsylvanian rocks exposed in the Worcester area (Perry and Emerson, 1903; Grew et al., 1970; Grew, 1973; also Grew, this Guidebook). Radiometric dating of the Ayer Granite (Zartman et al., 1965 and 1970; also more recent unpublished data of Zartman as summarized by Grew, this Guidebook) indicate that it is pre-Pennsylvanian, possibly as old as Ordovician.

Road Log

Starting point is the village green in center of Harvard, Massachusetts. We will assemble at the northeast corner of the triangular green a few yards east of and within sight of State Highway 111 at 1:30 P. M. on Friday. (This and Stops 1 and 2 are near the south edge of the Ayer 7 1/2 minute quadrangle. Stop 3 is in the Shirley 7 1/2 minute quadrangle).

Mileage

0.00 Proceed north on Route 111, passing exposures of "Unnamed Gneiss at Bare Hill Pond" (Hansen, 1956).

0.40 Turn left (N.W.) on Depot Street.

0.60 Stop 1: Pin Hill, for description see accompanying text.

0.60 Continue on Depot Street.

0.80 Stop 2: Ayer Granite, porphyritic phase. Turn right (N) on Mill Road, and park.
Alternate Stop 2A, weather and time permitting. Continue 0.70 mile northwest on Depot Street, then 1.1 mile southwest on Prospect Hill Road to highest point of road. Cut on left (E); Ayer Granite with primary feldspar foliation cut by aplite dikes. Panoramic view of Nashua Valley to west dominated by Mt. Wachusett (2006'), the highest peak in Massachusetts east of the Connecticut River. Mt. Wachusett lies at the west margin of the Fitchburg Granite pluton that marks the east edge of the broad central Massachusetts sillimanite zone of Acadian metamorphism. A narrow andalusite-sillimanite transition zone lies along the east margin of the pluton (Nelson, 1973), and the rocks exposed in the nearer lowlands are in the staurolite (± andalusite), garnet, and chlorite zones. Farther away to the northwest are Mt. Monadnock and the Wapack Range in New Hampshire held up by well bedded sillimanite schists of the Lower Devonian Littleton Formation. Return to Stop 2.

0.80 Proceed north and northeast on Mill Road.

1.45 Turn left (N) on Route 111.

2.10 Turn right (E) on ramp for Route 2, westbound.

2.25 Proceed west on Route 2, passing outcrops on both sides of Ayer Granite.

5.15 Cross Nashoba River and pass entrance to Fort Devens. Exposure on right (N) of highly folded ankerite-bearing schists of Unit 2 of Peck (in press)(Oakdale Formation).

6.00 Stop 3: Large outcrop on right of interbedded dark gray chlorite phyllite and sandstone. Excellent cleavage-bedding relationships in large fold with second generation crenulations in axial plane cleavage. Primary stratigraphic tops shown by cross-bedding in sandy layers, also by graded bedding. Phyllites and sandstones like these contain large chiastolites a few miles to the southwest. These rocks are believed to be older than the Ayer Granite. They are assigned by J. H. Peck (in press) to his Unit 3 in the adjacent Clinton Quadrangle. Unit 3 overlies Unit 2 (Oakdale Formation of Emerson) that may be tentatively correlated along strike with Silurian rocks in Maine. The rocks exposed at Stop 3 bear considerable similarity to parts of the Lower Devonian Littleton and Seeboomook Formations of western New Hampshire and Maine respectively. Some of the late structural features at Stop 3, as well as extensive retrograding of andalusite and staurolite in rocks to the southwest, may have been contemporaneous with deformational and metamorphic features observed at Stop 1.
End of trip.

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