Proterozoic tectonic history of the Hudson Highlands, Orange & Rockland Counties, New York

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New bedrock mapping in conjunction with new dating of Proterozoic rocks from the Hudson Highlands (Monroe & Sloatsburg Quadrangles) constrains the timing of tectonic events as well as provides possible evidence for the tectonic reconstruction of Rodinia (Proterozoic supercontinent). The crystalline rock of Orange and Rockland counties consists of belts of metasedimentary, metavolcanic and quartzofelspathic lithofacies that experienced a common intrusive, metamorphic and deformational history. The metasedimentary lithofacies consists of interlayered pelitic, calcsilicate and semipelitic gneisses that were metamorphosed up to granulite facies conditions. This is evident in pelitic and semipelitic rocks that contain biotite-garnet gneiss with orthoclase, plagioclase, quartz and sillimanite in addition to cordierite at some localities. The calcsilicate gneiss contains diopside, plagioclase, garnet, apatite, sphene, scapolite and hornblende and are migmatitic. The metavolcanic lithofacies consists of interlayered mafic, intermediate and felsic gneiss at all scales. The mafic rocks usually contain augite, hypersthene, hornblende, plagioclase and quartz with minor magnetite and biotite. The quartzofeldspathic gneiss contains foliated quartz and plagioclase with minor biotite and hornblende. These three lithofacies occur in belts that range from a few hundred meters to a few kilometers wide and the contact relationships are usually gradational. A suite of granite sills in the Sterling Forest area (Byram Intrusive Suite), consists of dozens of individual sheets that intruded parallel to the regional foliation (D1). Between the granite sheets, the country rock consists of narrow belts of the metavolcanic and metasediment lithofacies rocks. Individual granite sheets are parallel to penetrative foliation (S1) in the country rock, and generally strike 015-030 and dip 15-45 WNW. Granite sheet thicknesses range from a 10 to 100's of meters, and the thickest sheets can be traced over many kilometers. The contacts with the country rock are typically very sharp, and occasionally show finer grain size suggesting minor chill margins. However, most contacts show little textural or mineralogical evidence for contact metamorphism. Texturally the granite varies from medium grained (thinnest sheets) to coarse grained with the thickest sheets containing metacrystic K-feldspar and plagioclase. Most of the granite sheets contain minor amounts of hornblende or biotite.

The first deformational event in these rocks (D1) is characterized by penetrative foliation (S1) that affects all the lithofacies described above but excludes the suite of granite sheets. S1 is associated with intrafolial asymmetric isoclinal folds (F1) with consistent vergence in some areas. Meso- & megascopic folds are recumbent to shallowly reclined, and commonly asymmetric with sheared lower limbs. The fold asymmetry consistently indicates NW transport. Regionally the suites of granite sheets occur within the hinge region of map-scale recumbent antiforms (F1), and the structural stacking shows a pattern of thin sheets (<10 m) progressively giving way to thicker ones from the limb to the hinge of the fold. The lack of substantial contact metamorphic zones suggests the country rock was thermally comparable to the magma upon intrusion, pointing to probable intrusion during metamorphism. These observations are interpreted to imply that the intrusion of the granite sheets was syndeformational and structurally controlled. The D1 structures are crosscut by small diorite bodies that contain xenoliths of local gneiss.

Traversing across the strike of the Hudson Highlands in NY, there are numerous ductile shear zones (D2) that crosscut and transpose the D1 structures. The shear zones strike NE, are steeply dipping, and range from 0.5-2 km wide. Mineral lineations plunge shallowly NE, and kinematic indicators show dextral shear sense. Late deformation on these shear zones was dilational with mineralized veins form zones 1-5 km long. Upright open folds (F2) associated with shear zones have oblique hinge axes consistent with dextral shear and suggest a transpressional strain history.

Three zircon samples were analyzed using the SHRIMP lab at the Geological Survey of Canada to place time constraints on the events outlined above. Sample G1 was from a small diorite body that crosscuts the D1 features but is also crosscut by the late ductile shear zones (D2). Sample G2 was collected from one of the largest of the quartzofeldspathic gneiss bodies. Sample G5 was a pelitic gneiss from one of the belts of the metasedimentary rock. Peak Grenville metamorphic ages from the area yield 1010 +/- 7 Ma and 1007 +/- 4 Ma from two of the samples. The diorite pluton produced a cluster of concordant ages averaging 1008 +/- 4 Ma. This pluton is partially deformed in a dextral strike-slip shear zone, and therefore, this age provides an upper limit to the strike-slip event. The quartzofeldspathic gneiss sample produced a series of apparent protolith ages (strongly zoned zircon cores) ranging from 1230 to 1160 Ma. The metapelite sample contains multiply overgrown cores with a variety of concordant ages, most of which are typical for Grenvillian rocks. However, an age of 1491 +/- 8 Ma and an age of 2041 +/- 23 Ma was also produced from zircon cores from the same sample.