

## Acid Test Results

Footage	Drill Angle from Horizontal
163	60°
403	60°

**Notes:** Alteration may be the major difference between the gabbro and noritic gabbro units. Twelve thin sections are available for inspection. Hole logged on graphic form.

## CONDENSED GEOLOGIC LOG FOR DDH BM-1

Hole drilled at a 45 angle and an azimuth of 0.

**0'-38' Overburden.**

**38'-50' No core.**

**50'-173.1' Metamorphosed-recrystallized-altered, interbedded tuffs, flows, minor sills(?); and minor thin sediments and/or mylonite.** Sequence largely volcanic. Apparent compositions range from basaltic-andesitic (grey-green) to dacitic (green-grey) to microgranitic (pink-grey). Typically very fine-grained. Some intervals show gradational mafic to felsic changes (downward), where there is a sharp contact with the mafic rock directly below it. These intervals are at 67'-69.8', 69.8'-71.4' (slightly differentiated), and 138.5'-143.1'. 115'-126' and 149'-156' are similar except 125.4'-126' and 152'-156' show gradually increasing mafics with depth (result of chilling of flows? composition change if tuffs?). Other K-feldspar rich, irregular intervals within 143.2'-144.9', 158'-159', 162'-164.4', 168'-170', 172'-173.1'. More felsic-microgranite areas 35-60% K-feldspar; 20-35% hornblende, chlorite and biotite; 5-20% plagioclase; 10-20% quartz; 5-10% pyrite; and trace-1% chalcopyrite(?). More mafic and plagioclase rich intervals may be flows, breccia flows-tuffs, or sills; or may be parts of differentiated felsic intervals listed above. Local textures are pillowed and fragmental, although alteration and deformation obscure textures. Locally calcareous. Thin .1' black, cherty, interflow sediments or recrystallized ultramylonite(?) occur at 126', 143.1', 144.9', and 156.4'. Sulfides range from 1/4-20% and are generally pyrite with very minor chalcopyrite. Highest amounts occur in felsic intervals associated with veins and adjacent areas. Occasionally massive. Veins in unit are either hairline fractures with chlorite, quartz, calcite, pyrite, chalcopyrite and K-feldspar or larger, irregular veins-segregations with quartz, chlorite, calcite and pyrite. Fabric of rock is generally massive from recrystallization or was not as conducive to schistosity formation as other units.

Bedding-contacts are 18-59° to core axis with penetrative(1st?) schistosity averaging(?) 38° to core axis. Bedding often rotated subparallel to schistosity.

**173.1'-254.7' Green, fine-grained, chloritic, intermediate-mafic, crystal metatuff.** Probably recrystallized breccia flow tuff of andesitic to rhyodacitic(?) composition. Local pinkish K-feldspar (differentiation) 205.5'-206.5'. Hornblende phenocrysts ubiquitous, up to 2 mm in size. Plagioclase phenocrysts(?) scattered. Feldspar/mafic = 1. Moderately calcareous locally. Original recognizable volcanoclast sizes to 1 cm. Rock fabric semi-schistose; becoming more schistose with depth in general, probably reflecting finer original volcanoclast size. Also more laminated with depth. Minor, scattered calcite, K-feldspar, pyrite, and quartz(?) veins. Unit contains trace-1% pyrite and a trace of chalcopyrite. Sulfides occur in veins and disseminations. Schistosity is 55-66° (average 56°); with bedding often the same down to 38° to core axis.

**254.7'-451' Dark green-green grey metatuff-greywacke with minor phyllite.** In general, rock becomes less chloritic (green) and more silty-siliceous (grey) and calcareous with depth. Typically it is fine-grained. Rock more highly deformed (broken, folded, brecciated, pseudobrecciated) 257'-283', and has a well developed foliation. Deformed interval contains irregular quartz, pink dolomite-ankerite, and calcite veins with minor pyrite. Below 283' rock is more massive-semi-schistose and veins are irregular, and filled with quartz, chlorite and calcite. 401.5' has irregular bursts-veins with calcite, K-feldspar, minor black chlorite(?) and chalcopyrite. 427'-437' has scattered 1-2 mm hornblende phenocrysts. Superimposed bedding-schistosity is 40-75°, with bedding at 51-70°. Schistosity measures 22° and 57-63° to core axis. Two lineations are present.

**451'-641.5' Dark green-green grey metatuff-tuffaceous greywacke with minor graphitic phyllite laminae, veining and brecciation.** Graphitic phyllite from 451'-457', 635'-641.5', and often is associated with slip surfaces. 457'-635' is chloritic, fine-medium-grained, somewhat siliceous, with silty matrix. Locally moderately calcareous and broken. Core locally brecciated-pseudobrecciated-veined within 451'-496' (with dolomite-pyrite-calcite breccia cement); 529'-559' (with less dolomite, more clay gouge); and 631'-641.5' (graphitic). 467'-507' contains scattered veinlets of quartz, K-feldspar, calcite, dolomite, chalcopyrite and pyrite(?). 562'-582.5' similar, but less chalcopyrite, more pyrite. Vein paragenesis: quartz early; calcite, K-feldspar, pyrite early(?); dolomite later; and chalcopyrite last. Pyrite varies from 1/2-5%; chalcopyrite, trace-1/2%. Rock fabric is massive-semi-schistose, except with local schistosity associated with phyllites and slip surfaces. Bedding-schistosity measures 55-77° to core axis, and generally the two cannot be separated.

**641.5'-762' Black, graphitic-pyritic phyllite. Locally folded, broken and/or brecciated, with good penetrative cleavage.** Graphite is powdery, but shiny and crystalline on

slip surfaces. Pyrite is fairly ubiquitous (3-7%) and occurs as disseminations, concretionary masses, and occasionally as broken, corroded cubes. Trace chalcopryite; as coating on pyrite cubes, as cleavage fillings, and in hairline fractures cutting pyrite. Scattered quartz-dolomite-calcite veins with minor pyrite, some of which are deformed or, pseudobreciated. Minor tuffaceous component throughout, but also contains scattered fine-grained andesitic-dacitic crystal tuff beds. Phyllitic schistosity predominant fabric with bedding rotated-subparallel except in fold closures. Bedding-schistosity (superimposed) measures 32-80° to core axis. Bedding measures 0-80°, while schistosity measures 53-85°. Fold axial planes 55-66°, and 30-32°.

**762'-1022.9' Brown-grey, fine-medium-grained metatuff with minor argillite-phyllite.** Locally calcareous. Veining is minor but relatively ubiquitous. Largely semi-schist fabric with much flattening, recrystallization. Tuff is 20-60% plagioclase (locally altered to calcite), 5-20% quartz, 10-50% chlorite (basal 30' more chloritic), 0-20% biotite, and 0-30% actinolite. Also contains up to 5% pyrite and trace-1% chalcopryite. Tuff is andesitic-dacitic, but locally more K-feldspar bearing. Local quartz pebbles-eyes. Coarser volcaniclasts to 5 cm. Good cleavage, folding, slip surfaces in phyllites, with thicknesses up to 5.6'. Unit contains scattered quartz-dolomite-calcite-chlorite bursts and irregular veining. Other sulfides include the following: trace bornite in calcite veinlets with pyrite and chalcopryite 839'-846'; trace galena in 2 mm calcite-potassium feldspar vein with chalcopryite and pyrrhotite at 962'-963'; and bornite in 1 cm calcite-potassium feldspar-pyrrhotite-chlorite-chalcopryite vein at 966.8'. Base of unit hornfelsed? Bedding-schistosity (superimposed) measures 42-70° to core axis (65° average). Bedding measures all angles. Schistosity measures 45-68°. Axial planes measure 65-75° to core axis.

**1022.9'-1051.8' Dark grey-black, aphanitic, medium-grained gabbro dike with chilled contacts.** Mode: 50% plagioclase, 30% titanite, 10% olivine, 10% oxides. Not very magnetic for amount of oxides (ilmenite?). Rock massive without foliation; however, scattered fractures and serpentine-calcite-chlorite alteration occur in coarsest, central portion. Fractures often appear sheared with slickensides and minor pyrite. Pyrite averages a trace. Upper contact sharp but folded. Lower contact not distinct and grades into hornfelsed basalt.

**1051.8'-1243.2' Dark green-grey-green very fine-medium-grained metatuff-tuffaceous greywacke, and breccia flows(?).** Massive to semi-schistose. Recrystallization makes original texture difficult to recognize. Sediments and volcaniclasts interchange very gradationally. Largely tuffaceous with little sedimentary reworking. Mode: 30-35% chlorite, 30-35% actinolite-hornblende, 30-35% plagioclase, 0-10% calcite. Few scattered, thin sediment beds (phyllite, chert, argillaceous quartzite). 1070.6'-1071' black, porphyritic metadiabasic dike or sill (related? to previous unit). Scattered, irregular quartz-chlorite-calcite veins and segregations, some broken-mylonitic, some containing

pink dolomite, pyrite, pyrrhotite, chalcopryite, and biotite. All appear to be disrupted quartz veins with later carbonate, chlorite, and sulfides.

Unit contains trace-1% pyrite-pyrrhotite and trace-1/2% chalcopryite. Basal 40' shows gradual increase in graphitic argillite. Superimposed bedding-schistosity measures 43-75° to core axis. Bedding measures 60-68° and 42°. Schistosity measures 58-65°.

**1243.2'-1362' Interbedded-interlaminated dark grey-brown tuffaceous argillite, argillite, siliceous tuffs-sandstone, and light-medium tan grey marble and siliceous-silty marble.** Color depends on relative proportions of argillite, graphite, biotite versus felsic-siliceous tuffaceous material, calcarenite, and quartz sand. Tuffaceous rock appear to be biotitic, and semi-schistose to massive (recrystallized). Unit, in general, gets finer with depth. Finer-grained argillitic rock, often with 2 cleavages, but phyllitic texture only poorly-moderately developed. Folding shows up best in the argillites. Much flattening with many scattered slip surfaces throughout, with mylonitization in lower 50'. 1243.2'-1260.6', 1266.7'-1268.7' are argillaceous tuffs with plagioclase phenocrysts and quartz eyes. 1260.6'-1266.7', 1268.7'-1271.1' are argillitic, siliceous sandstone with pinkish, graded, sericitic (reworked?) tuff laminae (coarsen downward). 1271.1'-1276' siliceous, dolomitic fine-grained calcarenitic marble. 1276'-1299', 1331'-1362' are silty, altered, somewhat calcarenitic-dolarenitic tuffaceous argillite. 1299'-1331' interlaminated, folded argillites, siliceous tuff, and carbonates with local mylonitization.

Veining, more than in previous unit, is ubiquitous and usually less than 2 mm. Veins predominantly contain the following: calcite, quartz, pyrite, dolomite, pyrrhotite, K-feldspar, chlorite; along with minor amounts of chalcopryite, galena and sphalerite. Unit contains trace-4% pyrite, trace-1/2% chalcopryite, trace-1/2% sphalerite locally, and trace galena locally. Superimposed bedding-schistosity measures 25-30° and 42-80° (average 54°) to core axis. Bedding measures all angles. Schistosity measures 33-76°. Axial planes measure 50-67°.

**1362'-1545.8' Interlaminated-interbedded, pale-medium grey carbonate cemented quartzarenite-quartzite-quartz dolarenite; dark brown argillite; and pale orange-brown-tan siliceous tuffs.** Tuffs are sericitic and reworked. Sequence is largely graded, turbidite laminae, with local soft sediment deformation. Rock is massive to fairly schistose (sericitic tuffs). Much recrystallization; rock is now siliceous marble to carbonate quartzite to sericitic metatuff schist. Carbonate quartzarenite/tuff/argillite = 40/35/25. Local veining grades into pseudobreccia and breccia, which is scattered between 1372'-1479'. Hairline veinlets are scattered throughout and typically contain quartz, pyrite, calcite, dolomite, minor chalcopryite. Veinlets within 1362'-1404' contain voids, dolomite rhombs, black sphalerite (1/4%), pyrite, chalcopryite, galena (trace), chlorite and calcite. Rock averages trace-1/2% pyrite, pyrrhotite. Superimposed bedding-schistosity 43-65° to core axis. Bedding measures 0-56°. Schistosity measures 62-65°.

**1545.8'-3143' T.D.** Light to medium grey, recrystallized metadolomitic-calcareous quartzarenite and siliceous dolomitic marble. Lithology often laminated. Much folding, flattening, pseudobrecciation, and brecciation; yet rock is massive-recrystallized with breccia usually well healed. Much pressure solution, occasional stylolites. Breccia largely tectonic, although some may be sedimentary. Coloration variation due to graphite, pyrite, minor silt. Graphite occasionally concentrated into slip surfaces. Breccia's often associated with relatively undeformed tectonic slivers of rock. Mode is 0-90% quartz (average 35%); 0-30% calcite (15% average); 5-80% dolomite (45% average); and 0-80% graphite (5% average). Average 1/2% (?) pyrite. Siliceous intervals may be quartzarenite, chert, or silicified carbonate. Recrystallization makes textures obscure. Deformation increases downward from 1599'-1783.5' and is fairly continuous to 3143'. From 2689'-2727', 3029'-3043', core is somewhat broken and leached; with breccia not as well healed as usual. More siliceous (scattered) from 1701.5'-1748', 2115'-3143'. Local calcite-dolomite porphyroblasts to 1 cm are found locally 1559'-1654' and 1862'-1863.3'. Minor yellow tuff laminae from 1628.9'-1629'. Local minor pyrite (to 5%) associated with some argillitic marble, graphitic slip surfaces and breccia matrix. Veining is variable and is typically quartz-dolomite-calcite with complex cross-cutting relations that grade into pseudobreccia-breccia. Veins contain local vugs, with pyrite and chalcopryrite(?). Veining in general lessens below 1884'. They are locally brecciated, indicating continuing or multiple deformation. Some fold closures are very complex. Bedding measures at all angles to core axis. Schistosity-flattening most prominent feature, and is often superimposed on bedding, and measures 20-80° (increase downward?) with values predominantly 55-70°. Minor fold axial planes are 30-80° with most from 55-58°.

### Acid Test-Eastman Whipstock Survey Results

Footage	Acid Test Angle of Hole from Horizontal	Bedding-Structure Angle with Core Axis	Eastman-Whipstock Survey	
			Azimuth	Vertical Drift (from Horizontal)
50'	47°	-	-	-
53'	-	-	6°	46°
143'	-	53°S <sub>0</sub> -S <sub>1</sub>	356°	45°
343'	-	-	355°	43°
350'	44°	57°S <sub>0</sub> -S <sub>1</sub>	-	-
543'	-	-	354°	43°
650'	43°	62°S <sub>0</sub> -S <sub>1</sub>	-	-
743'	-	52°S <sub>1</sub> -S <sub>1</sub> Schistosity	351°	45°
943'	-	-	345°	49°
950'	48°	68°S <sub>0</sub> -S <sub>1</sub>	-	-
1143'	-	75°S <sub>0</sub> -S <sub>1</sub>	343°	49°
1250'	48°	48°S <sub>0</sub> -S <sub>1</sub> 0-5°S <sub>2</sub>	-	-
1343'	-	65°Ax Plane	340°	50°
1543'	-	43°S <sub>0</sub> -S <sub>1</sub>	338°	53°
1550'	53°	42°S <sub>0</sub> -S <sub>1</sub>	-	-

Footage	Acid Test Angle of Hole from Horizontal	Bedding-Structure Angle with Core Axis	Eastman-Whipstock Survey	
			Azimuth	Vertical Drift (from Horizontal)
1743'	-	39°S <sub>0</sub> -S <sub>1</sub>	336°	52°
1850'	53°	43°Ax Plane	-	-
1943'	-	62°S <sub>1</sub>	335°	51°
2143'	-	68°S <sub>1</sub>	333°	50°
2150'	51°	45°S <sub>0</sub>	-	-
2343'	-	30°Ax Plane	331°	49°
2450'	51 1/2°	0°S <sub>0</sub>	-	-
2543'	-	66°S <sub>1</sub> -S <sub>0</sub>	330°	49°
2743'	-	-	326°	49°
2750'	52°	45°S <sub>1</sub>	-	-
2943'	-	65°Qtz Vein	324°	48°
3143'	-	0-40°Vns	322°	48°

S<sub>0</sub> = Bedding

S<sub>1</sub> = 1st Folding Schistosity

S<sub>2</sub> = 2nd Folding Schistosity

**Notes:** Lithologic and structural logs are available for study, as are 156 thin sections and 48 other cut heels. Twelve individual and 95 composite samples were sent in for chemical analysis, with analytical results following in Table BM-1. Analytical results of rock samples taken in the area may be found in Table BM-2.

## CONDENSED GEOLOGIC LOG OF DDH A-2

Hole Drilled at a 45° angle and an azimuth of 180°.

0'-34' Overburden.

34'-40' No core.

**40'-194.5'** Fine-medium-grained, medium-dark grey brown-green brown, altered, recrystallized metabasalt-andesite flows and tuffs. Generally massive to semi-schistose. Some flattening evident. Mode: 20-65% calcite (partially in voids), 5-45% chlorite, 5-25% hornblende (needles to 5 mm), 5-35% biotite, 5-20% quartz and plagioclase and 0-5% pyrite-pyrrhotite(?), with a trace of chalcopryrite. Calcite, quartz, and sulfides occur as disseminations and in thin veinlets. Rock alternates between darker, more mafic, and lighter grey, more siliceous-calcareous intervals. Unit contains local pseudobreccia-breccia with scattered black ultramylonite bands. Minor thick veining and flow top breccia(?), with quartz-calcite-chlorite-pyrite and local traces of Mn oxides and rhodochrosite. Some veins appear brecciated and healed. Local pillows and flow tops. Layering-bedding-flattening oriented about 20-35° to core axis.