Mt. Holly & Ludlow
Re-issue of Open-File Report 94-229
Walsh, Ratcliffe, Dudley, and Merrifield

Note for the Monthly List:
This is a re-issue of the original Open-File Report. A third plate has been added to the report, but the data files remain unchanged. Includes digital files developed on an IBM compatible personal computer using PC ARC/INFO version 3.4D Plus. Both the paper copy, OF 94-229-A, and the database, OF 94-229-B, are available from the Vermont Agency of Natural Resources, Vermont Geological Survey, 103 South Main Street, Center Building, Waterbury, VT 05671-0301, telephone (802) 241-3608. Paper copy includes three plates: 62 by 34 inches, 44 by 34 inches, and 46 by 41 inches (in color), scale 1:24000 (1 inch = 2000 feet), $13.35; diskette copy includes two 3.5" DS/HD diskettes, $20.00.

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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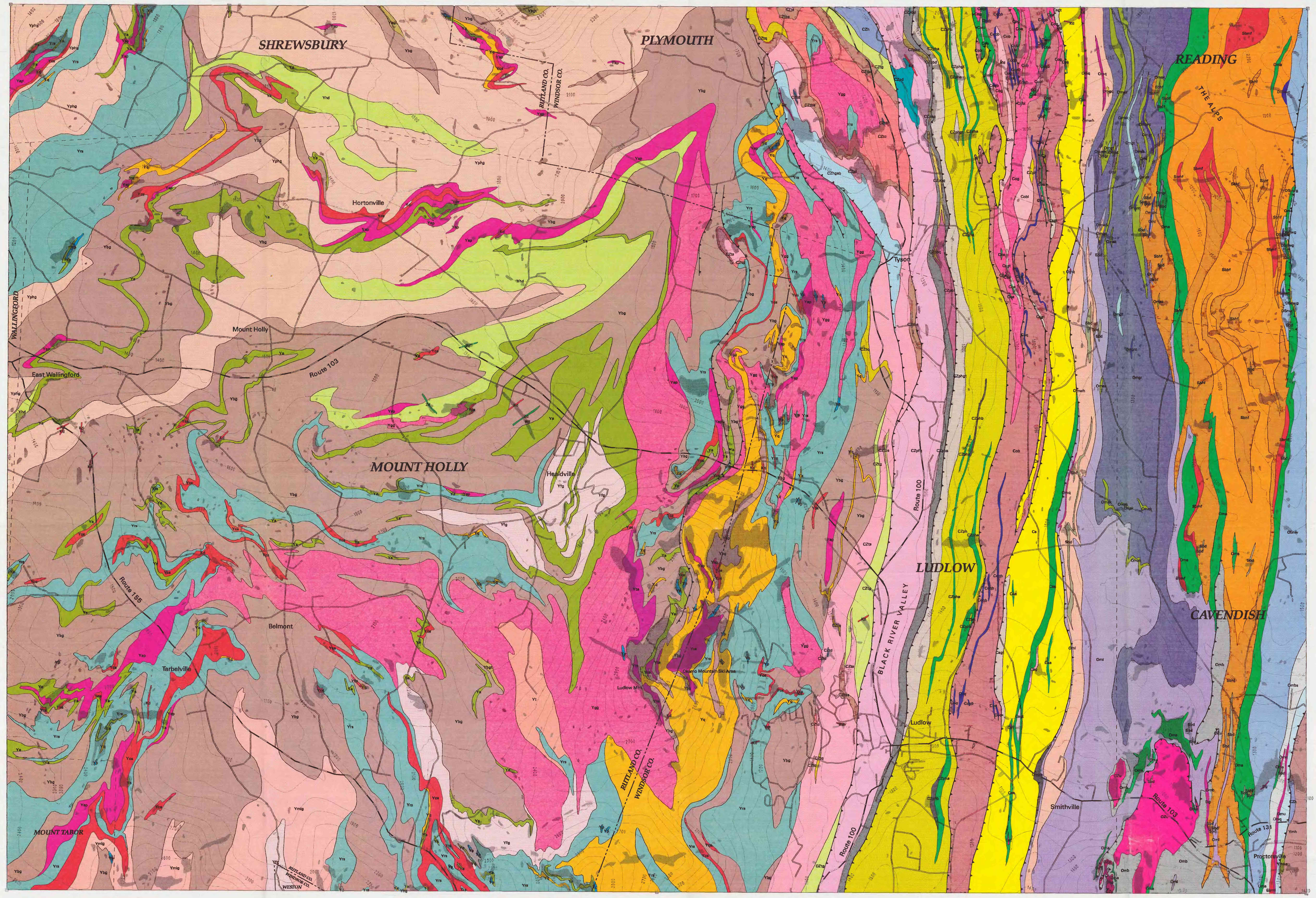
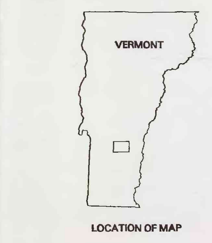


Topography modelled from USGS 7.5' DEM data
Contour interval 100 feet
National Geodetic Vertical Datum of 1929
Digital map units in State Plane Coordinate System
National Geodetic Horizontal Datum of 1927
Roads and town boundaries from the Vermont Center for Geographic Information, Inc.

SCALE 1:24000

Approximate Mean Declination 15°00' West, 1986



LOCATION OF MAP

Geology mapped by Ratcliffe in 1990 and 1991, assisted by Leon Sawyko in 1990; and by Ratcliffe and Walsh in 1992. Digitized by Merrifield and Walsh.

Digital Bedrock Geologic Map of the Mount Holly and Ludlow Quadrangles, Vermont and Explanation of the Bedrock Geology Database in the Vermont Geographic Information System

By
G.J. Walsh[1], N.M. Ratcliffe[1],
J.B. Dudley[2], and T. Merrifield[2]

1994

AUTHOR AFFILIATIONS
[1]U.S. Geological Survey
Reston, Virginia 20192
[2]Vermont Agency of Natural Resources,
Office of Information Management Services,
Waterbury, Vermont 05671

Description of Map Units

(Not necessarily in stratigraphic order; minerals listed in order of increasing abundance)

Symbol	Description
	CRETACEOUS DIKES
Kd	Lamprophyre
	DEVONIAN DIKES
Dg	Rhyodacite
Dbg	Biotite granite
	UNDIFFERENTIATED SILURIAN TO DEVONIAN NORTHFIELD AND WAITS RIVER FORMATIONS
DSnw	Dark-gray garnetiferous biotite-quartz-muscovite phyllite
DSnwc	Gray quartzite and quartz pebble conglomerate
DSnwg	Gray garnetiferous quartz-rich schist with coticule
	SILURIAN BARNARD GNEISS
Sbd	Metadiorite dike or sill
Sbbf	Biotite metatrondhjemite gneiss
Sbhf	Hornblende metatrondhjemite gneiss
Sbmf	Mixed metatrondhjemite with mafic schist and amphibolite
	UNDIFFERENTIATED LATE PROTEROZOIC TO ORDOVICIAN ULTRAMAFIC ROCKS
OZu	Serpentinite and talc-carbonate schist
	ORDOVICIAN MORETOWN FORMATION
Omu	Undifferentiated Oml and Omgr
Oml	Laminated gray-green quartz-plagioclase schist
Omgr	Light-green phyllitic quartzite and silvery-green plagioclase-biotite-muscovite-chlorite-quartz phyllite
Omwh	Gray small-garnet biotite-quartz-muscovite phyllite, and dark-gray to black graphitic biotite-quartz-muscovite phyllite
Oma	Dark-green amphibolite
Omak	Green ankeritic greenstone
Omgrc	Green small-pebble plagioclase-quartz conglomerate
Omgt	Gray garnetiferous plagioclase-biotite-muscovite-quartz schist
Omq	Tan feldspathic quartzite
Omgq	Gray garnetiferous quartzite
Ombb	Black cross-biotite quartz-muscovite schist
Omb	Black sulfidic carbonaceous quartz-muscovite schist
Ombs	Black carbonaceous metasiltstone
	CAMBRIAN STOWE FORMATION
Cs	Silvery-green biotite-chlorite-quartz-muscovite schist
Csa	Amphibolite and greenstone
Csgt	Silvery-green garnetiferous biotite-muscovite-quartz schist
Csg	Gray feldspathic cross-biotite schist
Cst	Talc schist
	CAMBRIAN OTTAUQUECHEE FORMATION
Cob	Dark-gray to black sulfidic graphitic quartz-muscovite phyllite
Coqb	Dark-gray to black quartzite
Coq	Tan quartzite
Cobi	Green cross-biotite chlorite-quartz schist
Cog	Gray feldspathic cross-biotite gneiss to schist
Coa	Amphibolite and greenstone
Cocr	White to green chromium-mica carbonate schist to quartzite
	CAMBRIAN TO LATE PROTEROZOIC PINNEY HOLLOW FORMATION
CZph	Silvery-green magnetite-chlorite-quartz-muscovite +/-chloritoid schist
CZpha	Amphibolite and greenstone
CZphgt	Silvery-green garnetiferous muscovite-quartz schist
CZphb	Dark-gray to black sulfidic carbonaceous quartz-muscovite schist
	CAMBRIAN TO LATE PROTEROZOIC PLYMOUTH FORMATION
CZpbs	Dark gray carbonaceous quartz phyllite with thin blue-gray dolostone
CZpbq	Gray vitreous quartzite
CZpbf	Gray-tan biotite feldspathic quartzite
CZpfq	Feldspathic quartz schist
CZpbd	Orange-brown to beige weathering dolostone
CZpd	Dark blue-gray and white mottled dolostone
	CAMBRIAN TO LATE PROTEROZOIC TYSON FORMATION
CZts	Lustrous chlorite schist to gray biotite-albite schist
CZtbs	Dark-gray carbonaceous sulfidic quartz phyllite
CZtg	Lustrous chlorite schist
CZtd	White to beige dolostone
CZtq	White quartzite
CZtc	Quartz-pebble and gneiss-pebble conglomerate
	CAMBRIAN TO LATE PROTEROZOIC HOOSAC FORMATION
CZh	Gray albitic schist
CZhgab	Gray magnetite-rich albitic granofels
	LATE PROTEROZOIC DIKES
Zd	Metadiabase dike
	MIDDLE PROTEROZOIC MOUNT HOLLY COMPLEX
Yp	Granite pegmatite
Yta	Tourmaline aplite
Ygg	Biotite granite gneiss
Yap	White feldspar-rich aplite and gneissic aplite
Yphg	Biotiote-rich granodiorite gneiss
Yhd	Hornblende-plagioclase gneiss
Ya	Amphibolite
Ybg	Biotite-quartz-plagioclase gneiss
Yrs	Rusty aluminous quartz schist
Ycs	Calc-silicate rocks including diopside gneiss, hornblende-diopside gneiss, diopside quartzite, and calcite marble
Yq	White vitreous quartzite
Ym	Calcite marble
Yd	Dolomite marble
Ybgt	Garnet-biotite-quartz-plagioclase schist to gneiss
Yt	Trondhjemite gneiss
Ymig	Migmatite gneiss
Yfg	Felsic magnetite gneiss
Ymh	Undifferentiated gneiss, quartzite, and calc-silicate rocks
Ymha	Amphibolite

Explanation of Map Symbols

Contacts

Outcrops (areas of exposed bedrock examined in this study)

Thrust fault, teeth on upper plate

1.0 Introduction

[illegible]

2.0 Map Preparation

[illegible]

Contacts -- lines for geologic unit polygons
Lithic Designators -- labels for geologic unit polygons
Ductile Faults -- lines for faults and labels for strike and dip points
Outcrops -- lines for outcrop polygons
Schistosity -- lines for form-lines and labels for strike and dip points
Gneissosity -- lines for form-lines and labels for strike and dip points
Cleavage -- lines for cleavage symbols and labels for strike and dip points
Brittle joints and faults -- lines for joint and fault symbols and labels for strike and dip points

[illegible]

3.0 Coverages

[illegible]

Plate 1:

Feature	Coverage Name	Coverage Type
Geologic Units	CONTACTS	polygon
Outcrops	OUTCROP	polygon
Ductile Faults	DUCFLTCL	line

Plate 2:

Feature	Coverage Name	Coverage Type
Ductile Faults	DUCFLTCL	line
Ductile Faults	DUCFLTPT	point
Schistosity	SCHISTCL	line
Schistosity	SCHISTPT	point
Gneissosity	GNEISSCL	line
Gneissosity	GNEISSPT	point
Cleavage	CRENCL	line
Cleavage	CRENPT	point
Joints & Faults	BRITCL	line
Joints & Faults	BRITPT	point

Figure 1 on Plate 3 illustrates the individual coverages by feature type at a scale of 1:100,000.

4.0 Plate 1 - Geologic Units and Outcrop Map

4.1 Contacts

[illegible]

4.2 Outcrops

[illegible]

4.3 Ductile Faults

[illegible]

5.0 Plate 2 - Structure Map

The representation of structural data is the most complex and time consuming task in the compilation of digital bedrock geologic maps. In order to present these data more clearly (or simply), form-lines and structure symbols are used to represent the prominent structural features in the Mount Holly and Ludlow quadrangles. Only a fraction of the structural data from the mapping are used to depict the structural geology; Plate 2, therefore, is a simplified structure map. In the PC ARC/INFO database each structure type (schistosity, gneissosity, etc.) is comprised of a line coverage, where the lines are graphic images, and a point coverage, where the points contain the strike and dip data. The structure symbols shown on Plate 2 were drawn from line and point coverages.

5.1 Schistosity and Gneissosity

Schistosity and gneissosity are types of foliation in metamorphic rocks. The orientation of a foliation is often shown on geologic maps with individual strike and dip symbols. On this map, the orientation is generalized and is illustrated with form-lines. Form-lines are interpretive, and are drawn by along-strike interpolation between individual strike and dip symbols. Essentially, form-lines are a graphical abstract of a geologic map's planar structural data. The form-lines represent the most prominent planar fabric in a given rock type, however, they do not distinguish between the multiple ages of foliations in the rocks. Additionally, we believe a reader unfamiliar with individual strike and dip symbols (a GIS user, for example) may find form-lines easier to understand than a collection of "stick" symbols. Less prominent planar structural features (cleavage, joints, etc.) are illustrated with individual strike and dip symbols. In the metamorphic rocks of the Mount Holly and Ludlow quadrangles the compositional layering is largely parallel to the foliation. Gneissosity form-lines depict the layering in the gneissic rocks of the Mount Holly Complex and the Barnard Gneiss, and schistosity form-lines depict the layering in all the other metamorphic rocks. Due to the limited number of bedding measurements and the fact that bedding is virtually parallel to the foliation, a bedding coverage is not included in this report.

In the database, the schistosity and gneissosity data are each contained in two coverages: a line coverage and a point coverage. The line coverage shows the general trend of the metamorphic foliation across the map, and the point coverage contains information on the orientation (strike and dip) of the foliation at a particular point on the map. The strike and dip symbols are drawn from the point coverages. The value of the dip is drawn from the point coverage.

5.2 Cleavage

Strike and dip symbols illustrete the cleavage present in the area. Cleavage is a planar break in the rocks that is less pervasive than the schistosity or gneissosity. The point of measurement is the center of the symbol. Like the form-lines, the cleavage symbols represent only a fraction of the cleavage data from the original mapping. Symbols ere located to illustrate the most common orientation of the cleavage in a given area. For example, in an area where many cleavage symbols indicated approximately the same orientation in the original mapping only one or two symbols were drawn for the simplified cleavage coverage.

In the database, the cleavage data are contained in two coverages: a line coverage and a point coverage. The line coverage contains the strike and dip symbol as it was originally drawn on the mylar separates, and the point coverage contains information on the orientation (strike and dip) of the cleavage. The value of the dip is drawn from the point coverage.

5.3 Brittle Features

Brittle features include brittle faults and joints. These features are the youngest structures in the bedrock and record a period of brittle deformation. Such fractures, or cracks, may significantly influence the flow of groundwater, and other fluids or gases, in the otherwise low-permeability bedrock of the Mount Holly and Ludlow quadrangles. Strike and dip symbols indicate the location of such features on the map. All brittle faults and joints that have been mapped are shown on Plate 2; these data have not been simplified from a larger data set. The brittle faults are drawn with arrows indicating the direction of relative lateral displacement and the letters "U" and "D" indicating up and down relative vertical displacement. Joints and joint sets were only measured in the vicinity of the Cretaceous dikes or on prominent cliff faces. Where the intersection point of two or more symbols coincides with the end of the strike and dip symbols, the intersection indicates the location of the measurement. In the database, the brittle fault and joint data are contained in two coverages: a line coverage and a point coverage. The line coverage shows the linear trend of the fault or joint, and the point coverage contains information on the orientation (strike and dip) of the fault or joint at a particular location on the map. The brittle fault point data also contain information on the relative horizontal or vertical displacement. The strike and dip symbols and the relative displacement symbols are drawn from the point coverages. The value of the dip is drawn from the point coverage.

6.0 Discussion

The Vermont Geographic Information System (VGIS) contains over 75 data layers ranging in scale from 1:5,000 to 1:250,000 (VCGI, 1991). The digital bedrock geologic map is a new addition to the VGIS, offering a new tool for evaluating the natural environment. Although the type of possible uses of these data will vary with the user, a few examples follow.

The data could be used for a preliminary evaluation of the radon potential in the Mount Holly and Ludlow quadrangles. Radon is a radioactive gas produced during the natural decay of uranium. Radioactivity studies show that certain map units in the Mount Holly Complex contain elevated levels of uranium (Skyline Labs, Inc., 1979; McHone and Wagener,1982). Rocks with the highest levels of uranium include tourmaline-bearing aplites and pegmatites (Yta and Yp), rusty aluminous quartz schist (Yrs), and quartzites (Yq). Grauch and Zarinski (1976) report anomalously high radioactivity from ultramafic rocks (OZu) in the Ludlow area. Gundersen and others (1993) and Gundersen and Schumann (1993) rate a number of rock types in Vermont with potentially high radon levels, many of which are found in the Mount Holly and Ludlow area. Faults and shear zones may also be areas of high radon potential (Gundersen and others, 1992). A radon potential map derived from the map units, ductile faults, and brittle features coverages could provide preliminary information for assessing the potential health risks associated with radon gas in the Mount Holly and Ludlow area.

The bedrock geologic data can be combined with the other VGIS data layers to derive maps for many other purposes. The bedrock geology could be combined with the source protection areas (SPAs) data layers to help communities and regulatory agencies better manage public and domestic water supplies. For example, an analysis of well location versus rock type may provide insight to factors affecting groundwater quality, especially in carbonate rocks, sulfidic rocks, or rocks containing elevated levels of uranium. The outcrops coverage used in conjunction with U.S. Soil Conservation Service soils data layers would provide the most comprehensive evaluation of exposed bedrock and shallow soils available. Such information would be useful for indicating areas that might require blasting and ledge removal during road construction. It would also be useful for preliminary evaluation of potential solid waste or subsurface wastewater disposal sites by indicating potential exclusion areas based on shallow depth to bedrock. By combining the hazardous waste sites (HWA) and pollution source inventory (PSI) data layers with the bedrock geology data layer, one could determine if any sites were located over areas susceptible to rapid contaminant migration such as carbonate rocks, faults, or brittle fractures. Figure 2 on Plate 3 illustrates how the geologic units can be combined with the DEM topography to provide new perspectives on how the bedrock geology influences the topography.

The addition of the bedrock geology database to the VGIS creates opportunities to develop a myriad of derivative maps not previously available, and it will enable Vermonters to make accurate assessments of factors which affect or are affected by the bedrock geology.

7.0 References

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U.S. GEOLOGICAL SURVEY

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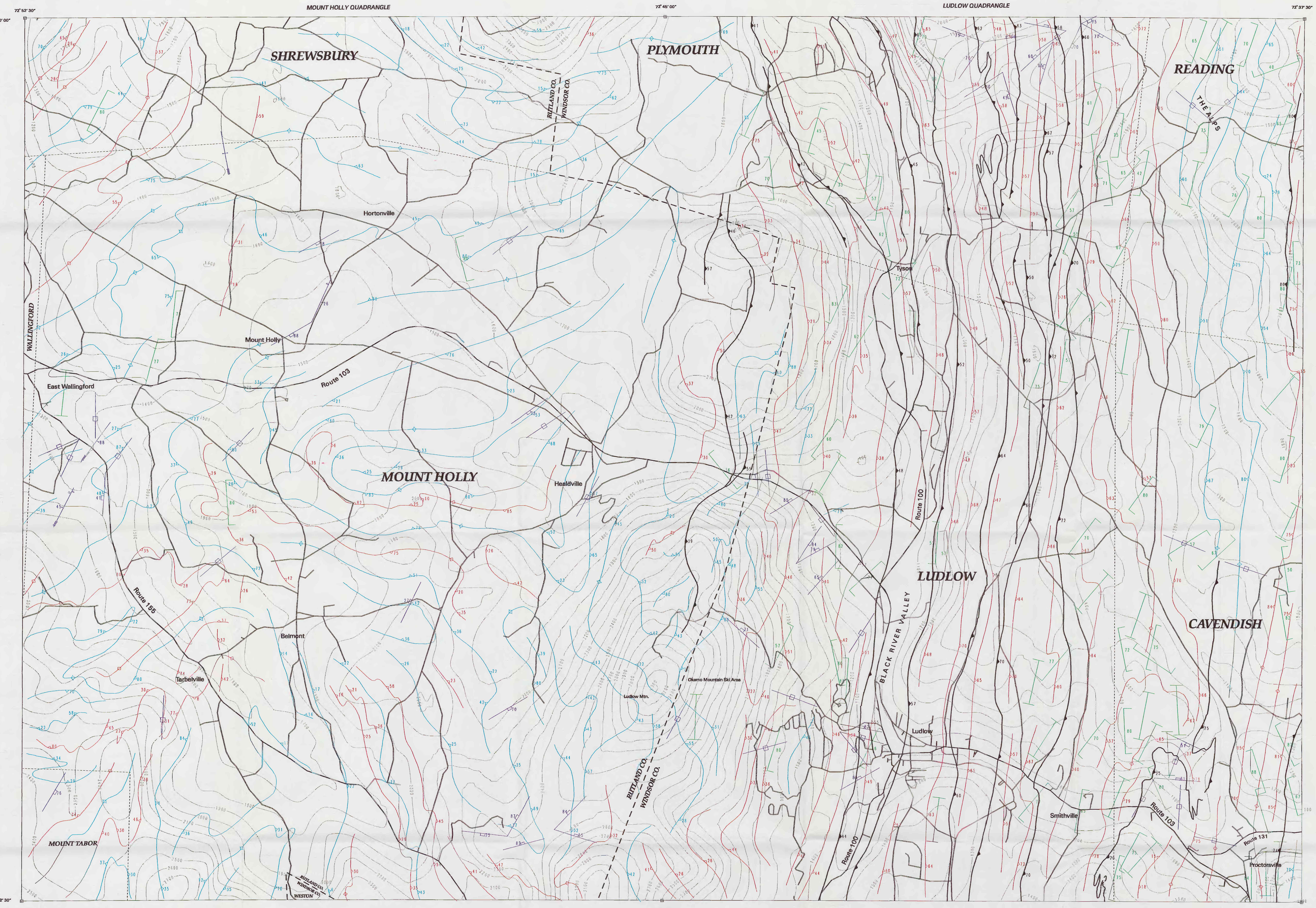
OPEN-FILE REPORT 94-229-A
STRUCTURE MAP
Plate 2 of 3



Schistosity
Strike and dip of inclined schistsoity
Strike and dip of vertical schistosity
Gneissosity
Strike and dip of inclined gneissosity
Strike and dip of vertical gneissosity
Brittle Features
Relative lateral displacement of brittle fault
Relative vertical displacement of brittle fault, U = up and D = down
Strike and dip of inclined brittle fault
Strike and dip of vertical brittle fault
Strike and dip of inclined joint
Strike and dip of vertical joint
Cleavage
Strike and dip of inclined cleavage
Strike and dip of vertical cleavage
Ductile Faults
Strike and dip of ductile fault

Topography modelled from USGS 7.5′ DEM data
Contour Interval 100 feet
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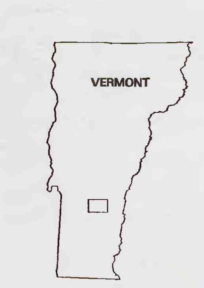
1994

SCALE 1:24000
1 .5 0 1 MILE
1 .5 0 1 KILOMETER
0 1 2 3 THOUSAND FEET

Approximate Mean Declination
15°00′ West, 1986



LOCATION OF MAP

AUTHOR AFFILIATIONS
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AGENCY OF NATURAL RESOURCES
GIS
VERMONT GEOGRAPHIC INFORMATION SYSTEM
HELPING VERMONTERS VISUALIZE CHOICE

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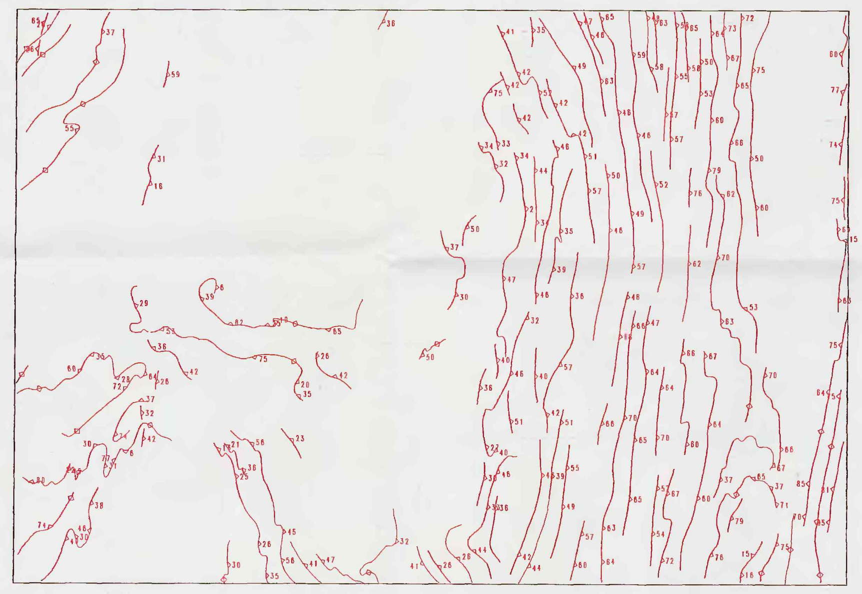
FIGURE 1.

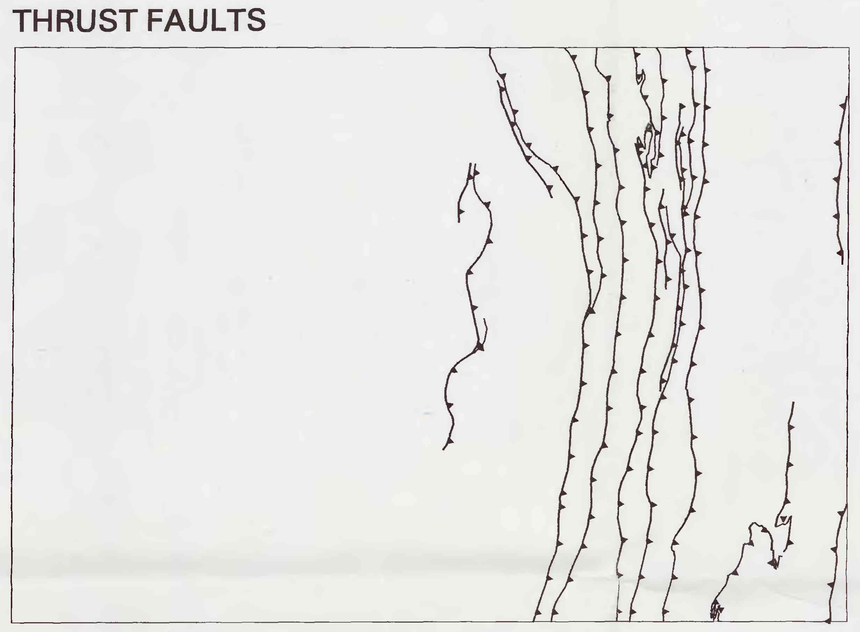
The eight maps shown below illustrate the data layers in the bedrock geology database of the Vermont Geographic Information System. The bedrock geology of the Mount Holly and Ludlow quadrangles was mapped at a scale of 1:24,000 and is shown here at a scale of 1:100,000 -- the scale of the new State bedrock geologic map. These maps show the level of detail that can be preserved in the transfer from large-scale to small-scale maps. The geologic units, thrust faults, outcrops, and joints and brittle faults represent complete datasets from the original geologic mapping. The schistosity, gneissosity, and cleavage layers represent derivative datasets developed by the authors of the geology from a subset of the total structural data. See Plates 1 and 2 for a complete explanation of map units and symbols.

GEOLOGIC UNITS

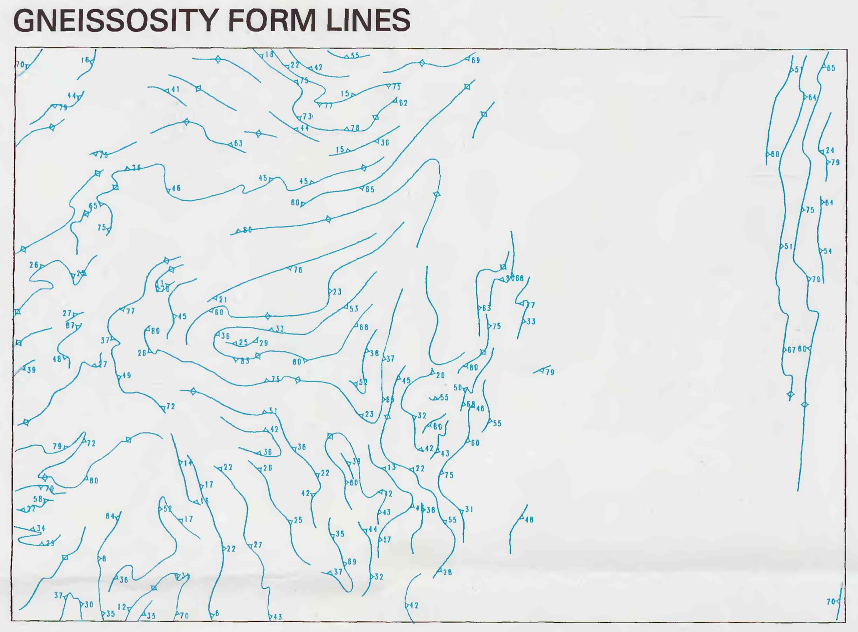
SCHISTOSITY FORM LINES



THRUST FAULTS

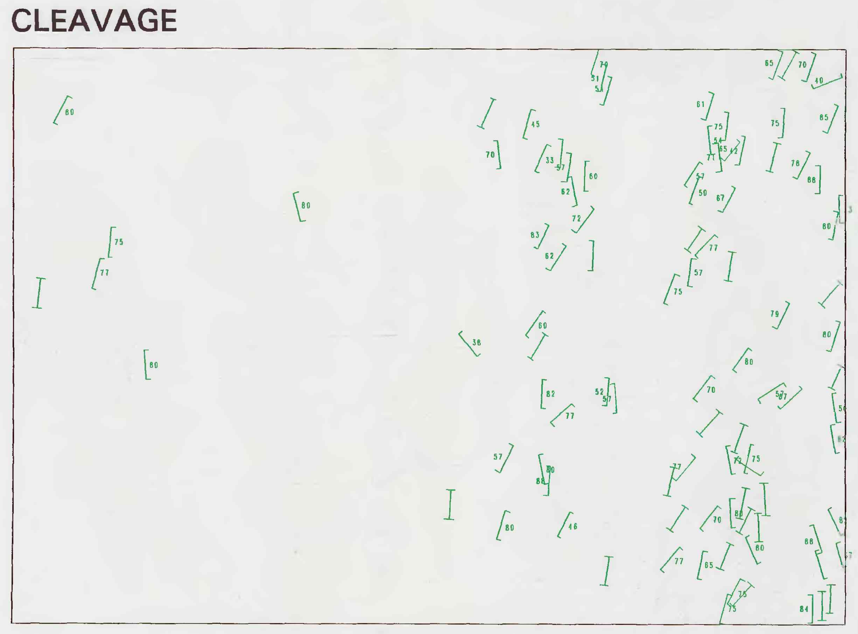


GNEISSOSITY FORM LINES

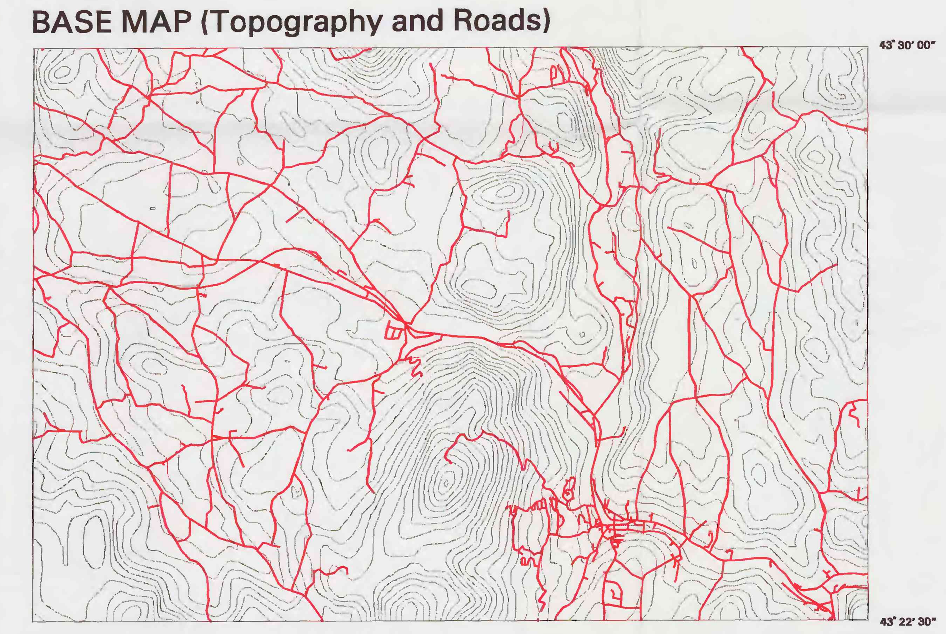


OUTCROPS

CLEAVAGE



BASE MAP (Topography and Roads)



JOINTS and BRITTLE FAULTS

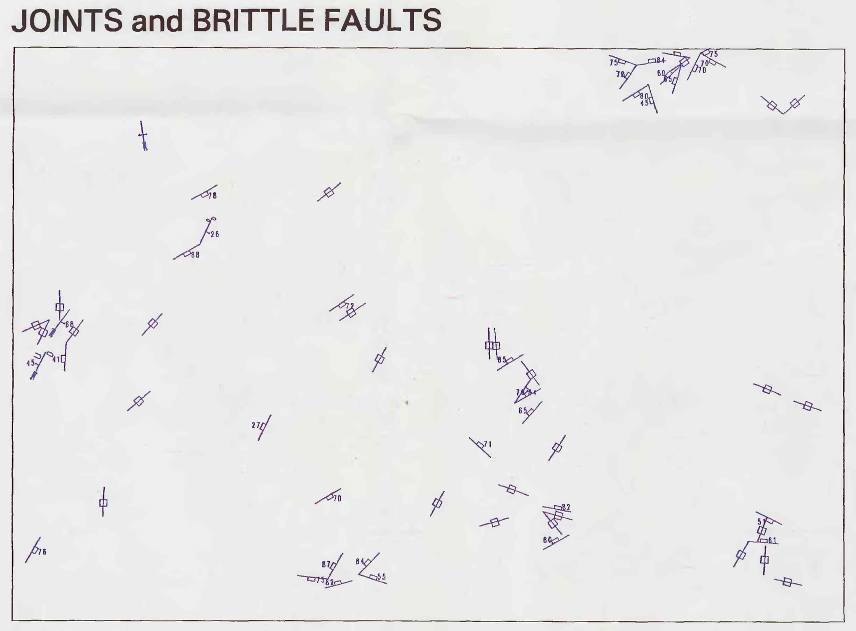
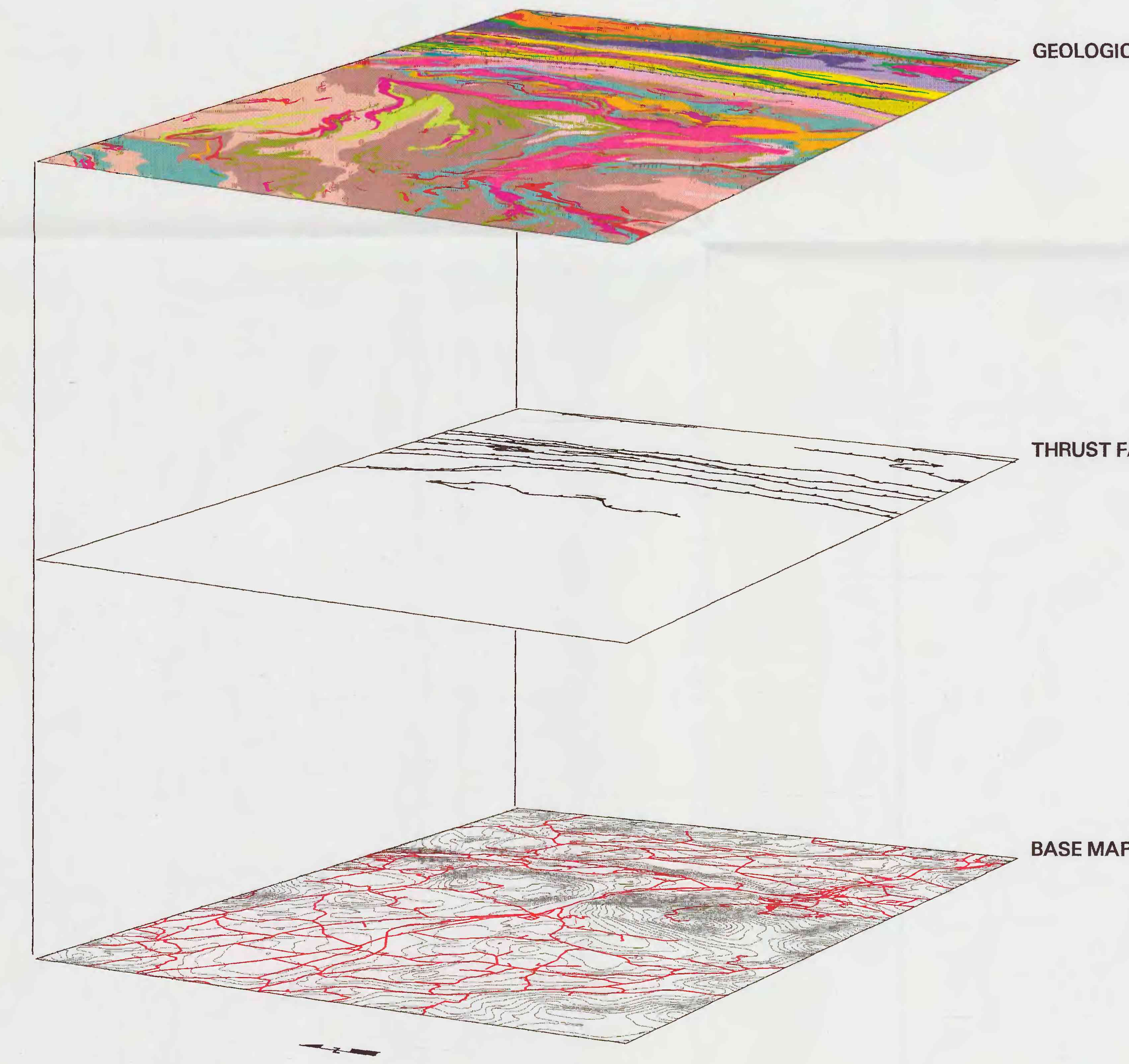
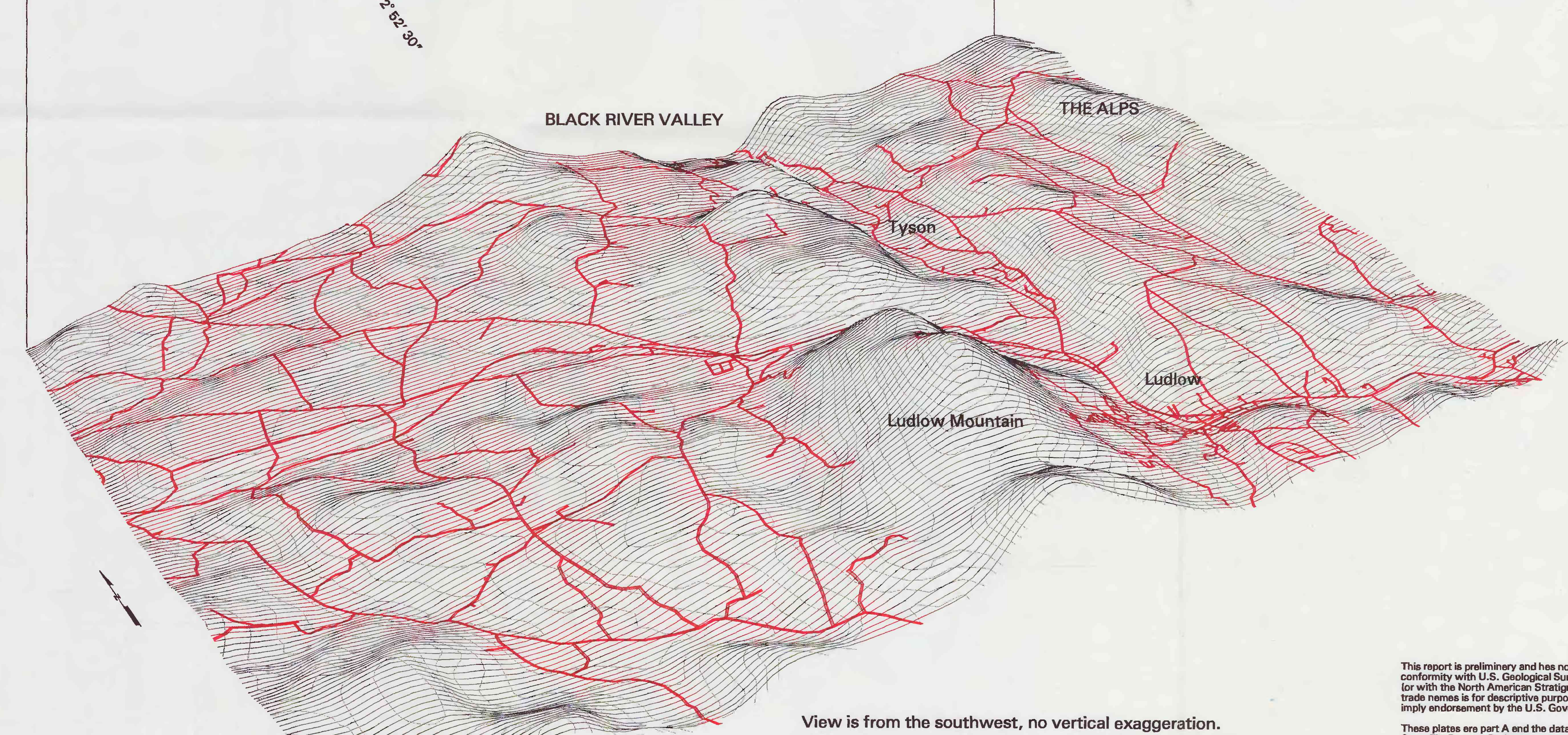


FIGURE 2.

The diagrams in figure 2 illustrate visual perspectives of three of the data layers from the Mount Holly and Ludlow quadrangles as viewed from the southwest. The topography data layer is based on USGS Digital Elevation Model (DEM) data and was used to generate the three-dimensional topography to produce the diagram shown below. The combination of these three layers shows how the digital database can be used to provide a unique look at how bedrock geology influences topography. Resistant gneisses and quartzites of the Middle Proterozoic Mount Holly Complex in magenta and gold underly much of Ludlow Mountain (Okemo Mountain Ski Area). Less resistant black schists and interlayered carbonate rocks of the Plymouth Formation in gray, pink, and blue underly the Black River Valley. Just to the east, however, the resistant muscovite-quartz schists of the Pinney Hollow Formation in greenish yellow support a prominent ridge where they have been thrust over the Plymouth Formation rocks. Still farther east, resistant rocks of the Barnard Gneiss in red and orange form the ridge know as "The Alps" between the villages of Tyson and Felchville.





View is from the southwest, no vertical exaggeration.
Approximate east-west dimension is 12.6 miles (20.2 kilometers).

AUTHOR AFFILIATIONS
[1]U.S. Geological Survey
Reston, Virginia 20192
[2]Vermont Agency of Natural Resources,
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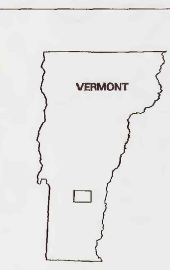

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For more info: http://geology.er.usgs.gov/gmapeast/vtp/vermont.html