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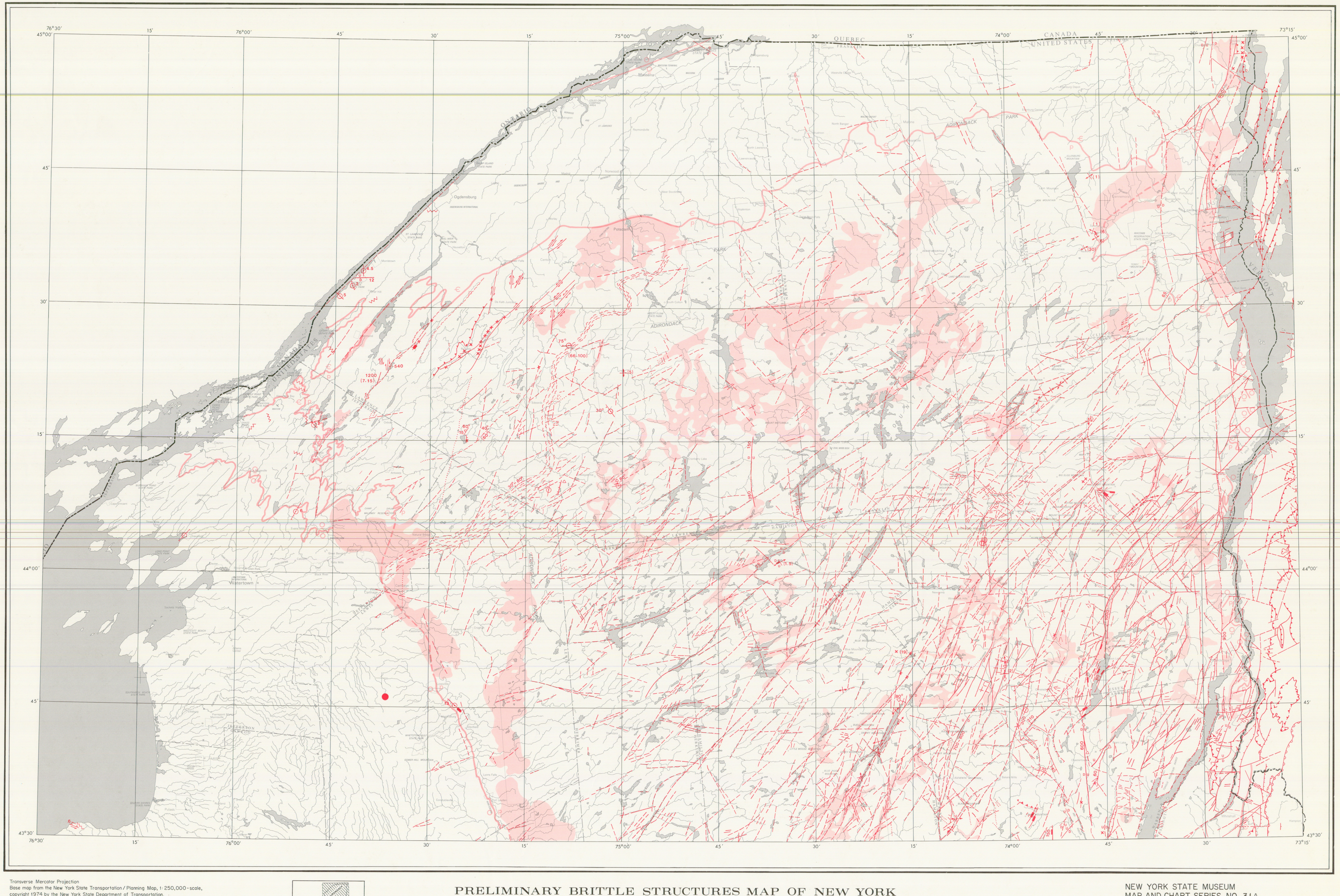
GEOLOGICAL SURVEY
James F. Davis, State Geologist



EXPLANATION

Introduction and Scope

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This publication consists of seven maps as follows:

- four map sheets at 1:250,000 showing faults and related information as well as photo-linear features;
- a composite, desk-size map showing this information at 1:500,000;
- a map at 1:1,000,000 showing joint data generalized by 15-minute quadrangle; and
- an index map keyed to the sources of information used in compiling the above maps.

These maps present all mappable data pertaining to faults, cataclastic zones, and joints that we could glean from the following sources: (1) the published and unpublished literature (210 references), (2) our photogeologic study of Landsat 1 (ERTS), Skylab, and high-altitude (U2) photographic products, (3) field checking of selected photo-lineaments, and (4) reconnaissance mapping of joints in thirty-nine 15-minute quadrangles. A separate Explanation is given for the accompanying Generalized Map of Recorded Joint Systems in New York.

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The Preliminary Brittle Structures Map was compiled using the following procedures:

1. All faults and prominent topographic lineaments shown on the 1971 Geologic Map were transcribed onto the new base map.
2. The original sources used in compiling the State Geologic Map were searched for additional information pertaining to these structures which could be shown on the present maps. These include such features as dip of fault planes, separation, location and width of breccias, and so on, as shown in legend.
3. The search was extended to the general literature and unpublished theses, maps, reports, and field notes, in order to obtain additional pertinent information.
4. A preliminary examination was made of bands 5 and 7 of the multispectral scanner imagery of Landsat 1 for New York State, dating from the time of launch in July 1972, through March 1974. The resolution of this imagery is 70-80 meters. The most informative of these images were then studied in detail at a scale of 1:500,000, to map photo-linear features, or lineaments. For the Adirondack region, with its relatively high density of faults, the imagery was also studied at 1:250,000. The identification numbers of the superior Landsat images, covering the period from launch through March 1973, have been listed elsewhere (Isachsen 1974b). Our use of the term lineament refers to any relatively sharp, straight alignment of drainage, topography, or tonal contrast which may be of natural origin. We believe that our identifications of lineaments have been conservative.
5. Several samples of Skylab color-infrared transparencies at 1:500,000, and multispectral scanner images at 1:1,000,000, were examined stereoscopically for additional linear features. Only a fraction of the lineaments found on the Landsat 1 imagery and high-altitude (U2) photography were observed, and no new ones were found. Consequently the remaining Skylab products were not studied intensively.
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7. The photo-lineaments were then screened to eliminate cultural and lithological lines and leave only those which might be controlled by some form of brittle deformation. The elimination of lithological lines (those which parallel the strike of bedding or foliation) introduces an unavoidable bias against fracture systems which may coincide with this trend. (This would apply, for example, to an analysis of the folded strata in the Hudson Valley and its border region to the west.) An exception to this elimination procedure was made for a small number of straight valleys which occur parallel to foliation in massive charnockite units in the Adirondacks; it was decided to include them on the map as possible fracture zones.

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Two other types of biases, one geological and the other cultural, may explain the relative paucity of linear features in the Hudson and Mohawk River valleys as well as in the Ontario Lowlands: (1) the burial of bedrock beneath an extensive cover of glacial deposits, and (2) the checkerboard pattern of agricultural land-use patterns in the region. The latter would camouflage any subtle (very low relief) topographic linears that might ordinarily have some hydrographic and/or botanical expression.

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Preliminary Nature of Maps

We wish to emphasize that we have designated the brittle structures map as "Preliminary." This is based on our growing conviction from field work that linear topographic features which cut across lithological boundaries and foliation are either fault traces or zones of closely-spaced joints, and that directed field work will confirm this prediction, at least in metamorphic terranes. Even during the present compilation, several linear Adirondack valleys were shown to be faults when isolated breccias noted in the literature were found to be aligned along their traces. The origin of tonal lines on the satellite imagery is more problematical. A number of these which were observed in the Adirondacks were found to be vegetation strips along straight stream courses of low relief (Isachsen 1974a). Other tonal lines, seen in forested areas on high-altitude aerial photographs, were totally lacking in topographic expression: these were interpreted as property lines and omitted from the compilation.

The brittle structures map is preliminary in yet another fundamental way. This may be seen in the complexity of the legend which was designed to encompass the wide range in precision of information given for faults in the literature. Thus, for example, information concerning individual faults ranges from relatively complete descriptions to mere point locations of faults or breccia zones. Here again, future directed field work may considerably sharpen and expand many of the present meager descriptions. In addition, new data pertaining to brittle deformation are currently being amassed at an accelerated rate because of the greatly expanded field activity connected with site selection for nuclear power plants. A prime example of this is the Hudson Highlands region, where only a portion of the recently-mapped faults could be shown at the scale of this compilation.

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Although most entries in the legend are self-explanatory, a number may require some elaboration:

1. Holocene "pop-ups", also termed "buckle-ups" and "compression ridges", were arbitrarily listed with "faults of unspecified type"
2. Where probable ages of faulting are given, they represent the conclusions of the author(s) of the sources used.
3. Retrograde chlorite in high-grade gneisses of the Adirondacks is invariably restricted to fault zones. For this reason, chlorite encountered in such gneisses in deep drill holes elsewhere in the State is interpreted to indicate the presence of faults in the buried basement.
4. In addition to the structural elements listed above, a number of non-brittle features are shown which bear on the spatial, temporal, and reactivation histories of the fault-lineament patterns. These include areas of extensive Quaternary alluvium, and the major unconformities which separate the Grenvillian, Quebecian, Taconian, Acadian, and Palisadian tectonic events.
5. The very few fault plane solutions which have been inferred from an analysis of seismograph data have been omitted from this preliminary edition. With the expanding capability of the Northeastern Seismic Network, however, fault plane solutions may be expected to increase both in number and precision, and become an important future map element.
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Applications

Among the potential applications of these maps are the following:

1. provide direction for future regional and local studies of brittle deformation.
2. provide a framework for the possible correlation of earthquake activity with existing fracture systems (i.e. seismotectonic analysis), and thus assist in the evaluation of possible sites for major engineering projects such as large dams, aqueducts, pipelines, and power generating plants.
3. identify major fracture conduits for groundwater recharge and circulation,
4. aid in the selection of exploration targets for oil, natural gas, and economic mineral deposits.

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LEGEND

Normal faults

60° — Normal fault, showing dip; hachures on realtively downthrown side; dashed where inferred.

Normal fault, low angle, dip not given; hachures on realtively downthrown side; dashed where inferred.

Normal fault, high angle, dip not given; hachures on realtively downthrown side; dashed where inferred.

Normal fault, nearly vertical; hachures on realtively downthrown side; dashed were inferred.

Subsurface normal fault observed in limestone cave

Faults of unspecified type and "pop-up" structures

80° — Inclined fault, with dip but not relative movement given, dashed where inferred.

Low angle fault with neither amount of dip nor movement given, dashed where inferred.

High angle fault with neither amount of dip nor movement given; dashed where inferred.

Vertical fault; relative movement not given; dashed where inferred.

D / U — Fault with relative movement given, but not attitude; dashed where inferred.

Fault trace; no other information given.

D / U — Subsurface fault, showing relative movement as inferred from drill hole data.

Fault less than 0.5 km long, with strike ± dip direction given (length of symbol exaggerated).

Fault location; no additional information given.

Holocene "pop-up" structures; i.e. superficial folds with axial fractures; length of symbol grossly exaggerated in order to show strike.

Reverse faults and gravity slides

Thrust fault; sawteeth on overthrust plate; dashed where inferred. Mostly of probable Late Taconian orogenic age in the Taconic region.

Thrust fault, sawteeth on overthrust plate; projected from observations in separate limestone caves.

High angle reverse fault; sawteeth on upthrown block. Of probable Acadian age in the Taconic region.

Gravity slide (rock into sediments); half-circles on sliding plate. Of Early Taconian orogenic age.

Strike-slip faults

Strike-slip fault, with relative movement shown by arrows. Of probable Quebecian and/or Early Taconian orogenic age in Taconic region.

Strike-slip fault, relative movement not given.

Fault which has experienced, at different times, both dip slip and strike-slip movement.

Shear zones

Zone of mylonite, ultramylonite, and/or mylonite gneiss.

70° — Shear zone along fault, showing dip of shear planes.

70° — Shear zone locailty, showing strike ± dip.

Localized shear zone, strike not given.

Linear features

Topographic linear feature observed on one or more of the following: topographic map, Landsat (ERTS), Skylab, or U-2 photographic product.

Tonal linear feature observed on Landsat or U-2 photographic product.

Additional features associated with faults

Fault breccia, either at isolated locality or along fault; arrow line indicates strike of breccia zone where given.

30 — Slickensides; numbered arrow indicates direction and amount of plunge where given; slickensides are very much more common than is recorded in the literature.

Fault breccia, with strike of zone and direction of slickensides given.

150 — Vertical (or horizontal) component of slip along normal (or strike-slip) fault, in meters; commonly a minimum estimate.

(62) — Width of fault zone or isolated breccia, in meters.

Drill hole showing retrograde chlorite in high grade basement gneisses; retrogression presumably due to faulting in basement.

Major unconformities resulting from orogenic or taphrogenic events

K / O — Cretaceous on Ordovician; Palisadian Taphrogeny and/or Alleghanian Orogeny.

Ʀ / p, Є, O — Triassic on Proterozoic, Cambrian, or Ordovician; Alleghanian and/or Acadian and/or Taconian Orogeny.

D / S, D — Lower Devonian on older Devonian or Silurian; beginning of Acadian Orogeny.

S, D / O — Silurian or Devonian on Ordovician; Taconian Orogeny.

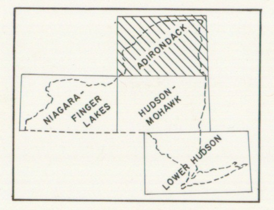
O / O — Middle Ordovician on Lower Ordovician; Quebecian (Penobscot) Orogeny (taphrogeny in New York). Not shown south of Hudson Highlands, where unconformity is intricately refolded. Along the southwestern border of the Adirondacks, this unconformity converges with that described below.

Є, O / p — Cambrian or Ordovician on Proterozoic; Grenville Orogeny, and, south of Hudson Highlands, Avalonian Orogeny; not shown south of Hudson Highlands, where unconformity is intricately refolded.

Factor limiting the expression of faults and other linear features

Area of extensive Quaternary alluvium.

Transverse Mercator Projection
Base map from the New York State Transportation / Planning Map, 1:250,000-scale, copyright 1974 by the New York State Department of Transportation.



PRELIMINARY BRITTLE STRUCTURES MAP OF NEW YORK

Adirondack Sheet

Yngvar W. Isachsen and William G. Mc Kendree

SCALE 1:250,000

STATUTE MILES

KILOMETERS

1977

NEW YORK STATE MUSEUM
MAP AND CHART SERIES NO. 31A

Preparation of this map was supported by U. S. Geological Survey Research Grant No 14-08-0001-G-151, and publication funds were provided by a U. S. Nuclear Regulatory Commission grant, Contract No. AT (49-24)-0297.

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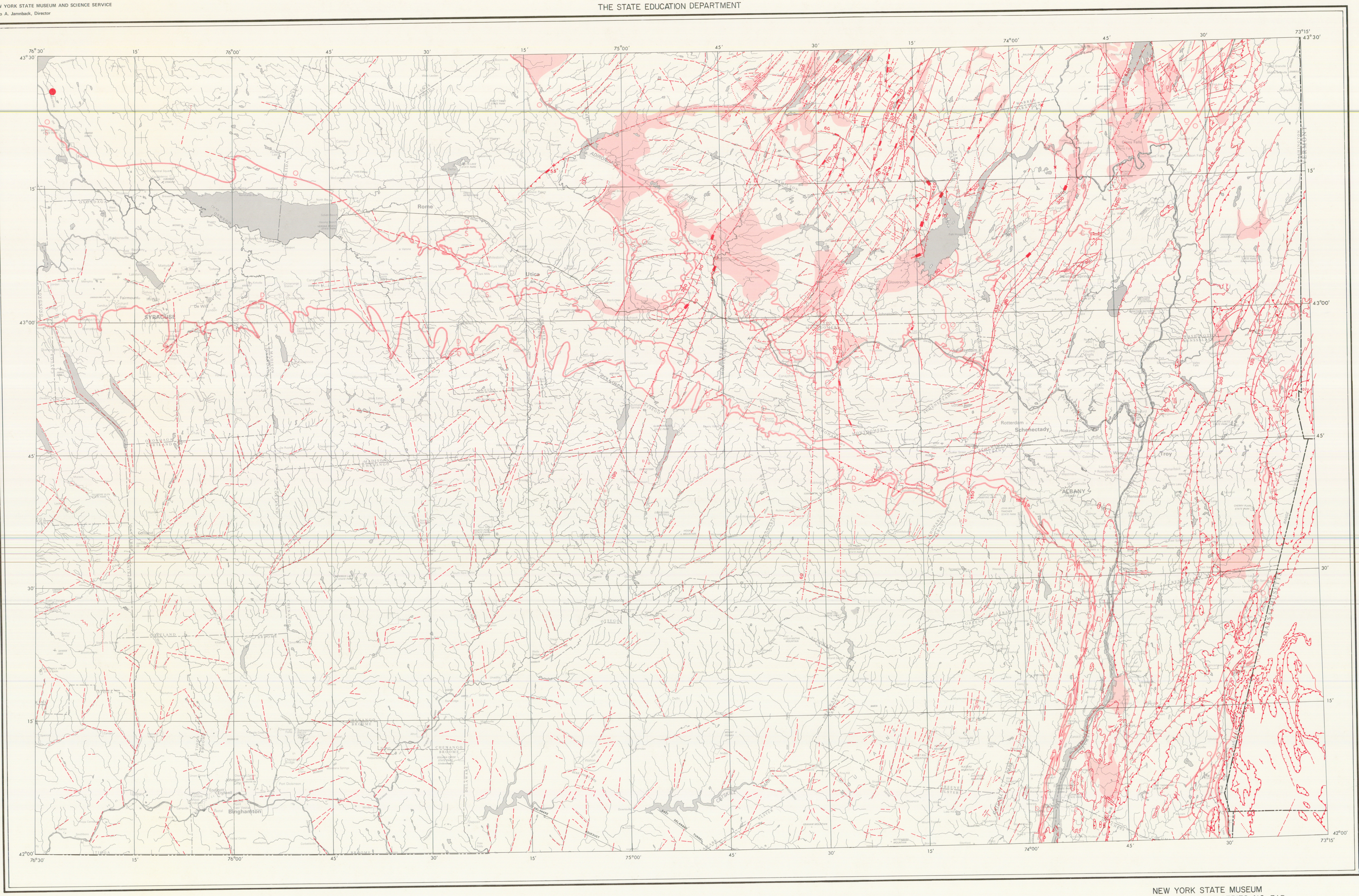

Transverse Mercator Projection
Base map from the New York State Transportation / Planning Map, 1:250,000-scale, copyright 1974 by the New York State Department of Transportation.

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Hudson - Mohawk Sheet

Yngvar W. Isachsen and William G. Mc Kendree

SCALE 1:250,000

1977

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Reverse faults and gravity slides

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- Thrust fault, sawteeth on overthrust plate; projected from observations in separate limestone caves.
- High angle reverse fault; sawteeth on upthrown block. Of probable Acadian age in the Taconic region.
- Gravity slide (rock into sediments); half-circles on sliding plate. Of Early Taconian orogenic age.

Strike-slip faults

- Strike-slip fault, with relative movement shown by arrows. Of probable Quebecian and/or Early Taconian orogenic age in Taconic region.
- Strike-slip fault, relative movement not given.
- Fault which has experienced, at different times, both dip slip and strike-slip movement.

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- Zone of mylonite, ultramylonite, and/or mylonite gneiss.
- 70° Shear zone along fault, showing dip of shear planes.
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- Topographic linear feature observed on one or more of the following: topographic map, Landsat (ERTS), Skylab, or U-2 photographic product.
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- Fault breccia, either at isolated locality or along fault; arrow line indicates strike of breccia zone where given.
- 30 Slickensides; numbered arrow indicates direction and amount of plunge where given; slickensides are very much more common than is recorded in the literature.
- Fault breccia, with strike of zone and direction of slickensides given.
- 150 Vertical (or horizontal) component of slip along normal (or strike-slip) fault, in meters; commonly a minimum estimate.
- (62) Width of fault zone or isolated breccia, in meters.
- Drill hole showing retrograde chlorite in high grade basement gneisses; retrogression presumably due to faulting in basement.

Major unconformities resulting from orogenic or taphrogenic events

- K / O Cretaceous on Ordovician; Palisadian Taphrogeny and/or Alleghanian Orogeny.
- ℞ / p, €, O Triassic on Proterozoic, Cambrian, or Ordovician; Alleghanian and/or Acadian and/or Taconian Orogeny.
- D / S, D Lower Devonian on older Devonian or Silurian; beginning of Acadian Orogeny.
- S, D / O Silurian or Devonian on Ordovician; Taconian Orogeny.
- O / O Middle Ordovician on Lower Ordovician; Quebecian (Penobscot) Orogeny (taphrogeny in New York). Not shown south of Hudson Highlands, where unconformity is intricately refolded. Along the southwestern border of the Adirondacks, this unconformity converges with that described below.
- €, O / p Cambrian or Ordovician on Proterozoic; Grenville Orogeny, and, south of Hudson Highlands, Avalonian Orogeny; not shown south of Hudson Highlands, where unconformity is intricately refolded.

Factor limiting the expression of faults and other linear features

- Area of extensive Quaternary alluvium.

NEW YORK STATE MUSEUM AND SCIENCE SERVICE
Hugo A. Jamnback, Director

THE UNIVERSITY OF THE STATE OF NEW YORK
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GEOLOGICAL SURVEY
James F. Davis, State Geologist

EXPLANATION

Introduction and Scope

The purpose of this explanation is to indicate the scope of the maps, as well as the general sources used and the methods of compilation -- and to identify them as preliminary working documents in a continuing study of the nature and history of brittle deformation in New York State. Earlier work was concerned largely with the extraction and preliminary evaluation of new geological information on Landsat 1 (ERTS) imagery, in a study supported by the National Aeronautics and Space Agency (Isachsen 1973, 1974a; Isachsen and others 1974). The present compilation and publications were supported by the United States Geological Survey and the Nuclear Regulatory Agency, respectively, as indicated in lower margins of maps.

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These maps present all mappable data pertaining to faults, cataclastic zones, and joints that we could glean from the following sources: (1) the published and unpublished literature (210 references), (2) our photogeologic study of Landsat 1 (ERTS), Skylab, and high-altitude (U2) photographic products, (3) field checking of selected photo-lineaments, and (4) reconnaissance mapping of joints in thirty-nine 15-minute quadrangles. A separate Explanation is given for the accompanying Generalized Map of Recorded Joint Systems in New York.

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2. The original sources used in compiling the State Geologic Map were searched for additional information pertaining to these structures which could be shown on the present maps. These include such features as dip of fault planes, separation, location and width of breccias, and so on, as shown in legend.

3. The search was extended to the general literature and unpublished theses, maps, reports, and field notes, in order to obtain additional pertinent information.

4. A preliminary examination was made of bands 5 and 7 of the multispectral scanner imagery of Landsat 1 for New York State, dating from the time of launch in July 1972, through March 1974. The resolution of this imagery is 70-80 meters. The most informative of these images were then studied in detail at a scale of 1:500,000, to map photo-linear features, or lineaments. For the Adirondack region, with its relatively high density of faults, the imagery was also studied at 1:250,000. The identification numbers of the superior Landsat images, covering the period from launch through March 1973, have been listed elsewhere (Isachsen 1974b). Our use of the term lineament refers to any relatively sharp, straight alignment of drainage, topography, or tonal contrast which may be of natural origin. We believe that our identifications of lineaments have been conservative.

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7. The photo-lineaments were then screened to eliminate cultural and lithological lines and leave only those which might be controlled by some form of brittle deformation. The elimination of lithological lines (those which parallel the strike of bedding or foliation) introduces an unavoidable bias against fracture systems which may coincide with this trend. (This would apply, for example, to an analysis of the folded strata in the Hudson Valley and its border region to the west.) An exception to this elimination procedure was made for a small number of straight valleys which occur parallel to foliation in massive charnockite units in the Adirondacks; it was decided to include them on the map as possible fracture zones.

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Two other types of biases, one geological and the other cultural, may explain the relative paucity of linear features in the Hudson and Mohawk River valleys as well as in the Ontario Lowlands: (1) the burial of bedrock beneath an extensive cover of glacial deposits, and (2) the checkerboard pattern of agricultural land-use patterns in the region. The latter would camouflage any subtle (very low relief) topographic linears that might ordinarily have some hydrographic and/or botanical expression.

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We wish to emphasize that we have designated the brittle structures map as "Preliminary." This is based on our growing conviction from field work that linear topographic features which cut across lithological boundaries and foliation are either fault traces or zones of closely-spaced joints, and that directed field work will confirm this prediction, at least in metamorphic terranes. Even during the present compilation, several linear Adirondack valleys were shown to be faults when isolated breccias noted in the literature were found to be aligned along their traces. The origin of tonal lines on the satellite imagery is more problematical. A number of these which were observed in the Adirondacks were found to be vegetation strips along straight stream courses of low relief (Isachsen 1974a). Other tonal lines, seen in forested areas on high-altitude aerial photographs, were totally lacking in topographic expression: these were interpreted as property lines and omitted from the compilation.

The brittle structures map is preliminary in yet another fundamental way. This may be seen in the complexity of the legend which was designed to encompass the wide range in precision of information given for faults in the literature. Thus, for example, information concerning individual faults ranges from relatively complete descriptions to mere point locations of faults or breccia zones. Here again, future directed field work may considerably sharpen and expand many of the present meager descriptions. In addition, new data pertaining to brittle deformation are currently being amassed at an accelerated rate because of the greatly expanded field activity connected with site selection for nuclear power plants. A prime example of this is the Hudson Highlands region, where only a portion of the recently-mapped faults could be shown at the scale of this compilation.

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Although most entries in the legend are self-explanatory, a number may require some elaboration:

1. Holocene "pop-ups", also termed "buckle-ups" and "compression ridges", were arbitrarily listed with "faults of unspecified type".

2. Where probable ages of faulting are given, they represent the conclusions of the author(s) of the sources used.

3. Retrograde chlorite in high-grade gneisses of the Adirondacks is invariably restricted to fault zones. For this reason, chlorite encountered in such gneisses in deep drill holes elsewhere in the State is interpreted to indicate the presence of faults in the buried basement.

4. In addition to the structural elements listed above, a number of non-brittle features are shown which bear on the spatial, temporal, and reactivation histories of the fault-lineament patterns. These include areas of extensive Quaternary alluvium, and the major unconformities which separate the Grenvillian, Quebecian, Taconian, Acadian, and Palisadian tectonic events.

5. The very few fault plane solutions which have been inferred from an analysis of seismograph data have been omitted from this preliminary edition. With the expanding capability of the Northeastern Seismic Network, however, fault plane solutions may be expected to increase both in number and precision, and become an important future map element.

6. Faults shown outside the New York State boundary were taken directly from the 1971 State Geologic Map, but no supplemental photogeologic or literature studies were made of these areas.

Applications

Among the potential applications of these maps are the following:

1. provide direction for future regional and local studies of brittle deformation.

2. provide a framework for the possible correlation of earthquake activity with existing fracture systems (i.e. seismotectonic analysis), and thus assist in the evaluation of possible sites for major engineering projects such as large dams, aqueducts, pipelines, and power generating plants.

3. identify major fracture conduits for groundwater recharge and circulation,

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LEGEND

Normal faults

- 60° Normal fault, showing dip; hachures on realtively downthrown side; dashed where inferred.
- Normal fault, low angle, dip not given; hachures on realtively downthrown side; dashed where inferred.
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- Normal fault, nearly vertical; hachures on realtively downthrown side; dashed were inferred.
- Subsurface normal fault observed in limestone cave

Faults of unspecified type and "pop-up" structures

- 80° Inclined fault, with dip but not relative movement given, dashed where inferred.
- Low angle fault with neither amount of dip nor movement given, dashed where inferred.
- High angle fault with neither amount of dip nor movement given; dashed where inferred.
- Vertical fault; relative movement not given; dashed where inferred.
- D U Fault with relative movement given, but not attitude; dashed where inferred.
- Fault trace; no other information given.
- D U Subsurface fault, showing relative movement as inferred from drill hole data.
- Fault less than 0.5 km long, with strike ± dip direction given (length of symbol exaggerated).
- Fault location; no additional information given.
- Holocene "pop-up" structures; i.e. superficial folds with axial fractures; length of symbol grossly exaggerated in order to show strike.

Reverse faults and gravity slides

- Thrust fault; sawteeth on overthrust plate; dashed where inferred. Mostly of probable Late Taconian orogenic age in the Taconic region.
- Thrust fault, sawteeth on overthrust plate; projected from observations in separate limestone caves.
- High angle reverse fault; sawteeth on upthrown block. Of probable Acadian age in the Taconic region.
- Gravity slide (rock into sediments); half-circles on sliding plate. Of Early Taconian orogenic age.

Strike-slip faults

- Strike-slip fault, with relative movement shown by arrows. Of probable Quebecian and/or Early Taconian orogenic age in Taconic region.
- Strike-slip fault, relative movement not given.
- Fault which has experienced, at different times, both dip slip and strike-slip movement.

Shear zones

- Zone of mylonite, ultramylonite, and/or mylonite gneiss.
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Factor limiting the expression of faults and other linear features

- Area of extensive Quaternary alluvium.

Transverse Mercator Projection
Base map from the New York State Transportation/Planning Map, 1:250,000-scale, copyright 1974 by the N.Y. State Department of Transportation.

PRELIMINARY BRITTLE STRUCTURES MAP OF NEW YORK

Lower Hudson

Yngvar W. Isachsen and William G. Mc Kendree

SCALE 1:250,000

STATUTE MILES

KILOMETERS

1977

NEW YORK STATE MUSEUM
MAP AND CHART SERIES NO. 31C

Preparation of this map was supported by U.S. Geological Survey Research Grant No. 14-08-0001-G-151, and publication funds were provided by a U.S. Nuclear Regulatory Commission grant, Contract No. AT(49-24)-0297.

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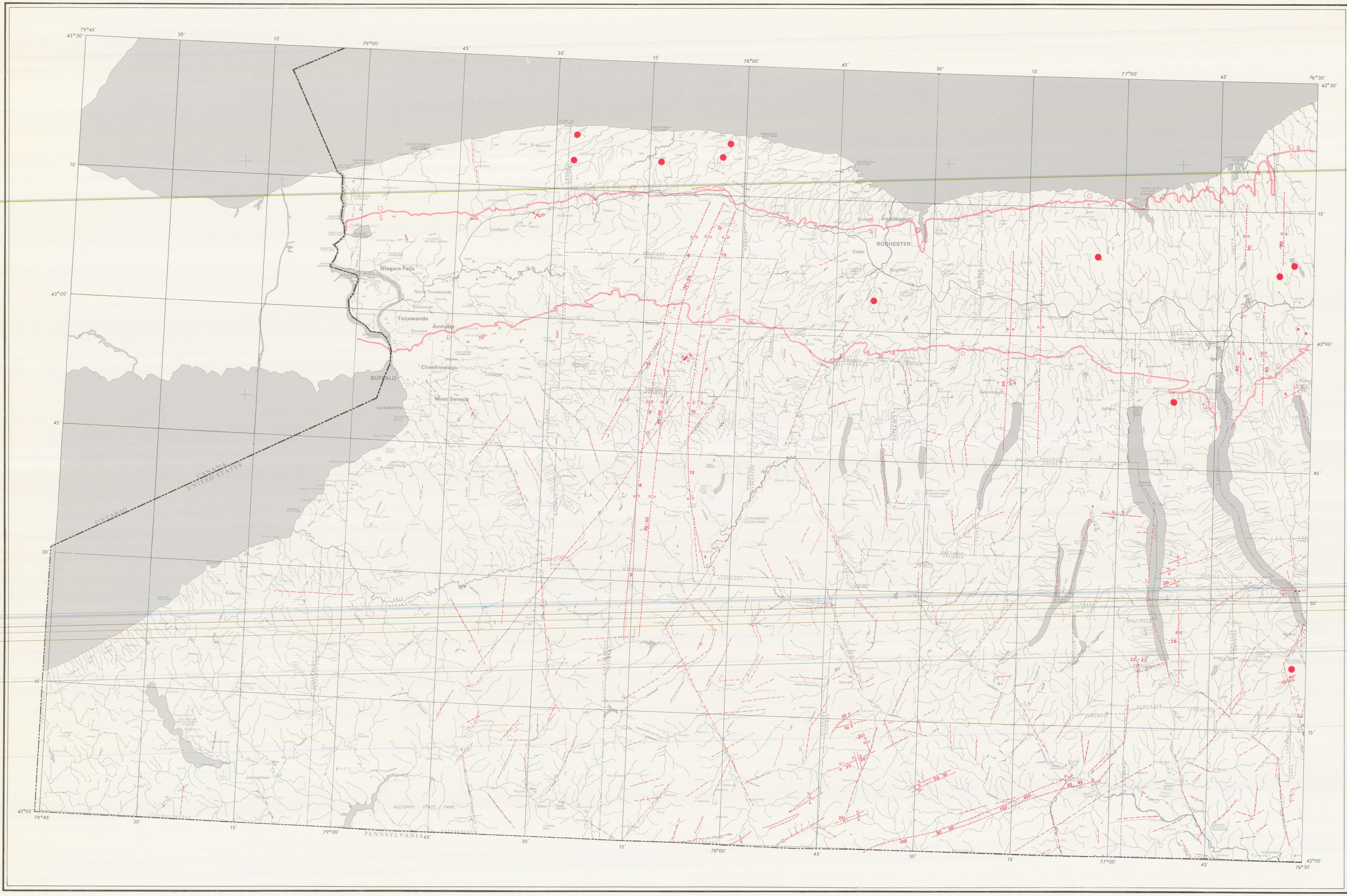

EXPLANATION

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Normal faults

60° Normal fault, showing dip; hachures on realtively downthrown side; dashed where inferred.

Normal fault, low angle, dip not given; hachures on realtively downthrown side; dashed where inferred.

Normal fault, high angle, dip not given; hachures on realtively downthrown side; dashed where inferred.

Normal fault, nearly vertical; hachures on realtively downthrown side; dashed were inferred.

Subsurface normal fault observed in limestone cave

Faults of unspecified type and "pop-up" structures

80° Inclined fault, with dip but not relative movement given, dashed where inferred.

Low angle fault with neither amount of dip nor movement given, dashed where inferred.

High angle fault with neither amount of dip nor movement given; dashed where inferred.

Vertical fault; relative movement not given; dashed where inferred.

D U Fault with relative movement given, but not attitude; dashed where inferred.

Fault trace; no other information given.

D U Subsurface fault, showing relative movement as inferred from drill hole data.

Fault less than 0.5 km long, with strike ± dip direction given (length of symbol exaggerated).

Fault location; no additional information given.

Holocene "pop-up" structures; i.e. superficial folds with axial fractures; length of symbol grossly exaggerated in order to show strike.

Reverse faults and gravity slides

Thrust fault; sawteeth on overthrust plate; dashed where inferred. Mostly of probable Late Taconian orogenic age in the Taconic region.

Thrust fault, sawteeth on overthrust plate; projected from observations in separate limestone caves.

High angle reverse fault; sawteeth on upthrown block. Of probable Acadian age in the Taconic region.

Gravity slide (rock into sediments); half-circles on sliding plate. Of Early Taconian orogenic age.

Strike-slip faults

Strike-slip fault, with relative movement shown by arrows. Of probable Quebecian and/or Early Taconian orogenic age in Taconic region.

Strike-slip fault, relative movement not given.

Fault which has experienced, at different times, both dip slip and strike-slip movement.

Shear zones

Zone of mylonite, ultramylonite, and/or mylonite gneiss.

70° Shear zone along fault, showing dip of shear planes.

70° Shear zone locailty, showing strike ± dip.

Localized shear zone, strike not given.

Linear features

Topographic linear feature observed on one or more of the following: topographic map, Landsat (ERTS), Skylab, or U-2 photographic product.

Tonal linear feature observed on Landsat or U-2 photographic product.

Additional features associated with faults

Fault breccia, either at isolated locality or along fault; arrow line indicates strike of breccia zone where given.

30 Slickensides; numbered arrow indicates direction and amount of plunge where given; slickensides are very much more common than is recorded in the literature.

Fault breccia, with strike of zone and direction of slickensides given.

150 Vertical (or horizontal) component of slip along normal (or strike-slip) fault, in meters; commonly a minimum estimate.

(62) Width of fault zone or isolated breccia, in meters.

Drill hole showing retrograde chlorite in high grade basement gneisses; retrogression presumably due to faulting in basement.

Major unconformities resulting from orogenic or taphrogenic events

K / O Cretaceous on Ordovician; Palisadian Taphrogeny and/or Alleghanian Orogeny.

Ʀ / p,Є,O Triassic on Proterozoic, Cambrian, or Ordovician; Alleghanian and/or Acadian and/or Taconian Orogeny.

D / S, D Lower Devonian on older Devonian or Silurian; beginning of Acadian Orogeny.

S,D / O Silurian or Devonian on Ordovician; Taconian Orogeny.

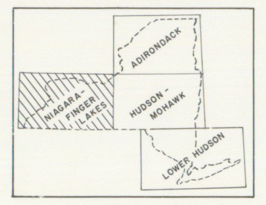
O / O Middle Ordovician on Lower Ordovician; Quebecian (Penobscot) Orogeny (taphrogeny in New York). Not shown south of Hudson Highlands, where unconformity is intricately refolded. Along the southwestern border of the Adirondacks, this unconformity converges with that described below.

Є,O / p Cambrian or Ordovician on Proterozoic; Grenville Orogeny, and, south of Hudson Highlands, Avalonian Orogeny; not shown south of Hudson Highlands, where unconformity is intricately refolded.

Factor limiting the expression of faults and other linear features

Area of extensive Quaternary alluvium.

Transverse Mercator Projection
Base map from the New York State Transportation/Planning Map, 1:250,000 - scale, copyright 1974 by the New York State Department of Transportation.



PRELIMINARY BRITTLE STRUCTURES MAP OF NEW YORK

Niagara-Finger Lakes Sheet

Yngvar W. Isachsen and William G. Mc Kendree

SCALE 1:250,000
5 0 5 10 15 20 STATUTE MILES
5 0 5 10 15 20 25 30 KILOMETERS

1977

NEW YORK STATE MUSEUM
MAP AND CHART SERIES NO. 31D

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PRELIMINARY BRITTLE STRUCTURES MAP OF NEW YORK

Yngvar W. Isachsen and William G. Mc Kendree

SCALE 1:500,000

1977

EXPLANATION

Introduction and Scope

The purpose of this explanation is to indicate the scope of the maps, as well as the general sources used and the methods of compilation -- and to identify them as preliminary working documents in a continuing study of the nature and history of brittle deformation in New York State. Earlier work was concerned largely with the extraction and preliminary evaluation of new geological information on Landsat 1 (ERTS) imagery, in a study supported by the National Aeronautics and Space Agency (Isachsen 1973, 1974a; Isachsen and others 1974). The present compilation and publications were supported by the United States Geological Survey and the Nuclear Regulatory Agency, respectively, as indicated in lower margins of maps.

This publication consists of seven maps as follows:

- four map sheets at 1:250,000 showing faults and related information as well as photo-linear features;
- a composite, desk-size map showing this information at 1:500,000;
- a map at 1:1,000,000 showing joint data generalized by 15-minute quadrangle; and
- an index map keyed to the sources of information used in compiling the above maps.

These maps present all mappable data pertaining to faults, cataclastic zones, and joints that we could glean from the following sources: (1) the published and unpublished literature (210 references), (2) our photogeologic study of Landsat 1 (ERTS), Skylab, and high-altitude (U2) photographic products, (3) field checking of selected photo-lineaments, and (4) reconnaissance mapping of joints in thirty-nine 15-minute quadrangles. A separate Explanation is given for the accompanying Generalized Map of Recorded Joint Systems in New York.

Selection of the base map for this compilation involved two requirements: (1) that it be a transverse mercator projection and have a scale of 1:250,000, in order to match the projection and scale of the existing State geologic map (Fisher and others, 1971) and state gravity map (Diment and others, 1973), and (2) that it contain the most accurate representation of drainage available, inasmuch as drainage shows such a sensitive response to brittle deformation. The 1974 map of the New York State Department of Transportation fits these requirements well. It was constructed using topographic quadrangle maps at 1:24,000, except in the Adirondacks where the largest scale then available was 1:62,500. All streams were retained in the 1:250,000 reduction except those shorter than 3 km.

Method of Compilation

The Preliminary Brittle Structures Map was compiled using the following procedures:

1. All faults and prominent topographic lineaments shown on the 1971 Geologic Map were transcribed onto the new base map.
2. The original sources used in compiling the State Geologic Map were searched for additional information pertaining to these structures which could be shown on the present maps. These include such features as dip of fault planes, separation, location and width of breccias, and so on, as shown in legend.
3. The search was extended to the general literature and unpublished theses, maps, reports, and field notes, in order to obtain additional pertinent information.
4. A preliminary examination was made of bands 5 and 7 of the multispectral scanner imagery of Landsat 1 for New York State, dating from the time of launch in July 1972, through March 1974. The resolution of this imagery is 70-80 meters. The most informative of these images were then studied in detail at a scale of 1:500,000, to map photo-linear features, or lineaments. For the Adirondack region, with its relatively high density of faults, the imagery was also studied at 1:250,000. The identification numbers of the superior Landsat images, covering the period from launch through March 1973, have been listed elsewhere (Isachsen 1974b). Our use of the term lineament refers to any relatively sharp, straight alignment of drainage, topography, or tonal contrast which may be of natural origin. We believe that our identifications of lineaments have been conservative.
5. Several samples of Skylab color-infrared transparencies at 1:500,000, and multispectral scanner images at 1:1,000,000, were examined stereoscopically for additional linear features. Only a fraction of the lineaments found on the Landsat 1 imagery and high-altitude (U2) photography were observed, and no new ones were found. Consequently the remaining Skylab products were not studied intensively.
6. A stereoscopic analysis was made of cloud-free high-altitude (U2) color-infrared transparencies (scale 1:130,000) which were flown by NASA for the eastern portion of the State. This high resolution photography covers a north-south strip 60 km wide which extends from the eastern border of the State to 74°30' west longitude, and from New York City to 44°30' north latitude. The coverage also includes a strip 70 km wide which extends southeastward from Alexandria Bay on the St. Lawrence River to the aforementioned north-south strip. This photography has a resolution of about 3 meters where tonal contrast is high, and its use resulted in the discovery of numerous linear features not seen in the Landsat imagery.
7. The photo-lineaments were then screened to eliminate cultural and lithological lines and leave only those which might be controlled by some form of brittle deformation. The elimination of lithological lines (those which parallel the strike of bedding or foliation) introduces an unavoidable bias against fracture systems which may coincide with this trend. (This would apply, for example, to an analysis of the folded strata in the Hudson Valley and its border region to the west.) An exception to this elimination procedure was made for a small number of straight valleys which occur parallel to foliation in massive charnockite units in the Adirondacks; it was decided to include them on the map as possible fracture zones.

Other factors bias the photogeological data (e.g. Isachsen 1973). In particular, it should be noted that the southeast azimuth of solar illumination for Landsat imagery creates shadow-enhancement of straight valleys orthogonal to the illumination direction, but diminishes the visibility of those parallel to it.

Two other types of biases, one geological and the other cultural, may explain the relative paucity of linear features in the Hudson and Mohawk River valleys as well as in the Ontario Lowlands: (1) the burial of bedrock beneath an extensive cover of glacial deposits, and (2) the checkerboard pattern of agricultural land-use patterns in the region. The latter would camouflage any subtle (very low relief) topographic linears that might ordinarily have some hydrographic and/or botanical expression.

Another factor that influences the mapping of photo-linear features is the scale at which the imagery is studied: the smaller the scale, the larger the features detected (e.g. Isachsen and others 1974). Thus, for example, at scales two or more orders of magnitude smaller, the Hudson-Champlain Valley would appear as a single mega-lineament. In the present compilation this "line" is a composite of hundreds of faults and photo-lineaments. This should not obscure the possibility that the "Hudson-Champlain hydrographic line" of Hobbs (1903) may be a fundamental tectonic lineament.

Preliminary Nature of Maps

We wish to emphasize that we have designated the brittle structures map as "Preliminary." This is based on our growing conviction from field work that linear topographic features which cut across lithological boundaries and foliation are either fault traces or zones of closely-spaced joints, and that directed field work will confirm this prediction, at least in metamorphic terranes. Even during the present compilation, several linear Adirondack valleys were shown to be faults when isolated breccias noted in the literature were found to be aligned along their traces. The origin of tonal lines on the satellite imagery is more problematical. A number of these which were observed in the Adirondacks were found to be vegetation strips along straight stream courses of low relief (Isachsen 1974a). Other tonal lines, seen in forested areas on high-altitude aerial photographs, were totally lacking in topographic expression: these were interpreted as property lines and omitted from the compilation.

The brittle structures map is preliminary in yet another fundamental way. This may be seen in the complexity of the legend which was designed to encompass the wide range in precision of information given for faults in the literature. Thus, for example, information concerning individual faults ranges from relatively complete descriptions to mere point locations of faults or breccia zones. Here again, future directed field work may considerably sharpen and expand many of the present meager descriptions. In addition, new data pertaining to brittle deformation are currently being amassed at an accelerated rate because of the greatly expanded field activity connected with site selection for nuclear power plants. A prime example of this is the Hudson Highlands region, where only a portion of the recently-mapped faults could be shown at the scale of this compilation.

Legend

Although most entries in the legend are self-explanatory, a number may require some elaboration:

1. Holocene "pop-ups", also termed "buckle-ups" and "compression ridges", were arbitrarily listed with "faults of unspecified type".
2. Where probable ages of faulting are given, they represent the conclusions of the author(s) of the sources used.
3. Retrograde chlorite in high-grade gneisses of the Adirondacks is invariably restricted to fault zones. For this reason, chlorite encountered in such gneisses in deep drill holes elsewhere in the State is interpreted to indicate the presence of faults in the buried basement.
4. In addition to the structural elements listed above, a number of non-brittle features are shown which bear on the spatial, temporal, and reactivation histories of the fault-lineament patterns. These include areas of extensive Quaternary alluvium, and the major unconformities which separate the Grenvillian, Quebecian, Taconian, Acadian, and Palisadian tectonic events.

5. [illegible]

6. [illegible]

Applications

Among the potential applications of these maps are the following:

1. provide direction for future regional and local studies of brittle deformation.
2. provide a framework for the possible correlation of earthquake activity with existing fracture systems [illegible]
3. identify [illegible] circulation, [illegible]
4. aid in [illegible] economic mineral deposits.

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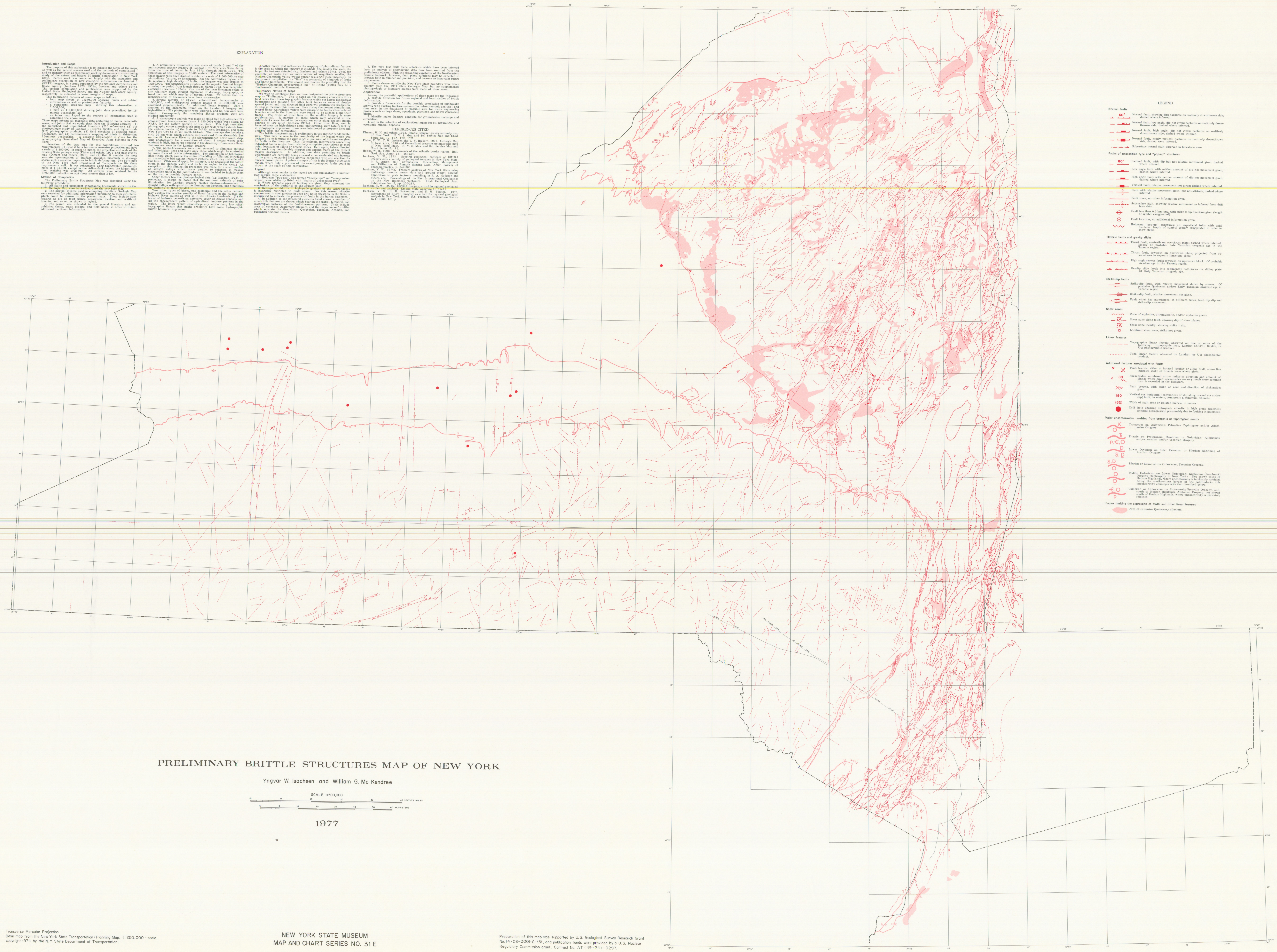
Isachsen, Y. W., [illegible]

Isachsen, Y. W., [illegible]

Isachsen, Y. W., [illegible]

Isachsen, Y. W., [illegible]



Transverse Mercator Projection
Base map from the New York State Transportation/Planning Map, 1:250,000 - scale, copyright 1974 by the N.Y. State Department of Transportation.

NEW YORK STATE MUSEUM
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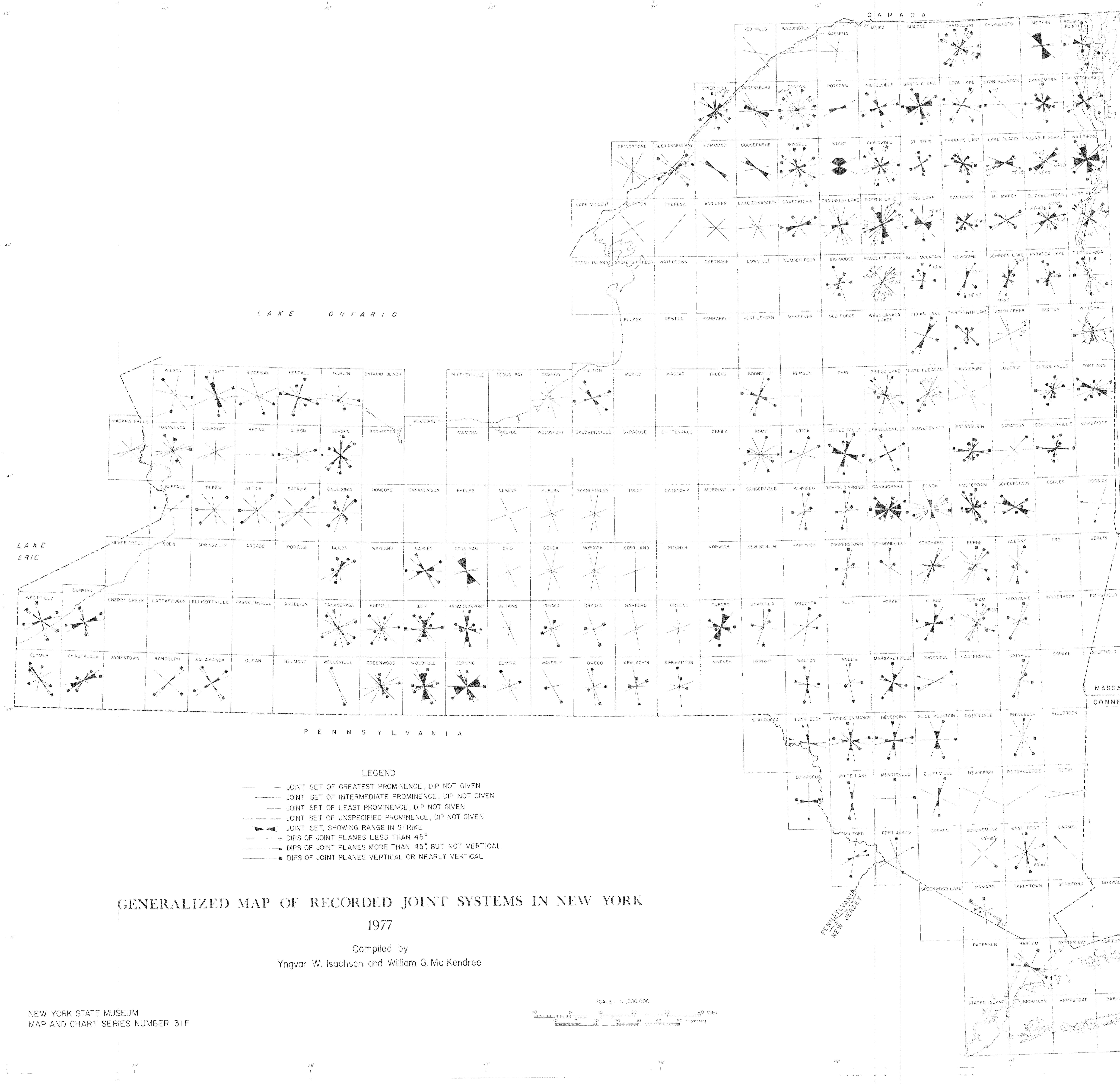
Preparation of this map was supported by U.S. Geological Survey Research Grant No. 14-08-0001-G-151, and publication funds were provided by a U.S. Nuclear Regulatory Commission grant, Contract No. AT (49-24)-0297.



EXPLANATION

This generalized map of joint systems in New York State was compiled from the measurements of some 60 workers whose contributions span the time period 1899 to 1976. The joint data were obtained from published and unpublished sources and are here generalized, by 15-minute quadrangle, in the form of qualitative rose diagrams. We consider the mapping technique used by Hodgson (1961) to be superior for regional joint pattern analysis, but the varied methods of data presentation in the literature did not permit this approach. The Legend was designed to retain the great variations in precision that appear in the published and unpublished literature. Sheeting structures were only rarely mentioned in the literature and are not included in the compilation.

In searching the literature we were surprised to find that although most of the State is covered by some scale of bedrock mapping, many maps and reports contain no reference to jointing. In numerous other publications the joint information was highly generalized, with strikes or ranges in strike given in a few sentences, but with no information as to dip. Elsewhere dips were simply classified as "steep to vertical," a category which would fail to distinguish between vertical joints and conjugate sets dipping 60 or 70 degrees. Such a distinction would be critical, for example, in evaluating the possibility that some joint-controlled linear valleys in the Allegheny Plateau may be related to reactivated basement faulting (Isachsen and others, 1971).

When the plotting of joint data from the literature was completed, it became clear that in only about 40 percent of the State did any information on jointing exist. We therefore devoted a field season to reconnaissance mapping of joints in broad areas of western New York and the Adirondacks to help "fill out" the map. We cast our data in the same modified rose diagram format that was used to plot the joint data compiled from the literature. Because ours was a reconnaissance study, with the goal of covering as many 15-minute quadrangles as possible in one field season, stations were chosen on the basis of easy accessibility. Within this limitation, an effort was made to obtain as broad a coverage across each quadrangle as possible and to visit 10-20 outcrop stations. We averaged 12 stations per quadrangle, and 30 readings per station. At most exposures these 30 readings represented several times as many individual joints because we recorded only one joint attitude per set, along with average spacing for the set, rather than measuring all joints in a set.

At each station, strikes and dips were recorded for all joint sets. In addition, the following joint characteristics were recorded: spacing (the reciprocal of frequency), maximum length and height (commonly limited by exposure dimensions), persistence (whether throughgoing, or terminating against other joints), planar vs. curved, surface relief, surface markings, surface coatings, and host rock lithology. We summarized the orientation and frequency data for each quadrangle and, reviewing the other parameters measured, made qualitative decisions as to which joint orientations were sufficiently prominent (i.e. above "background" values) to show on the map.

We are not aware of other attempts to compile joint data for so extensive an area, and regard the present map only as a preliminary working document that may contribute towards an ultimate understanding of the origin, history, and tectonic significance of joints. The limitations of the data can be seen both in the vagaries of the legend and in the common lack of consistency of joint set orientations in adjacent quadrangles. Towards the need for improved data gathering in the future, it is not inappropriate to quote Hobbs (1903, p. 500) who long ago wrote:

> "Comparatively few geologists have put on record the directions of prevailing joints within the regions which they have studied. Until such studies have been undertaken the fragmentary records now at hand must be found insufficient for the satisfactory correlation throughout large areas."

For genetic classification of joints and interpretations of joint patterns in particular areas, the reader is referred to the references used in the compilation.

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LEGEND

- JOINT SET OF GREATEST PROMINENCE, DIP NOT GIVEN
- JOINT SET OF INTERMEDIATE PROMINENCE, DIP NOT GIVEN
- JOINT SET OF LEAST PROMINENCE, DIP NOT GIVEN
- JOINT SET OF UNSPECIFIED PROMINENCE, DIP NOT GIVEN
- JOINT SET, SHOWING RANGE IN STRIKE
- DIPS OF JOINT PLANES LESS THAN 45°
- DIPS OF JOINT PLANES MORE THAN 45°, BUT NOT VERTICAL
- DIPS OF JOINT PLANES VERTICAL OR NEARLY VERTICAL

GENERALIZED MAP OF RECORDED JOINT SYSTEMS IN NEW YORK

1977

Compiled by
Yngvar W. Isachsen and William G. Mc Kendree

SCALE 1:1,000,000

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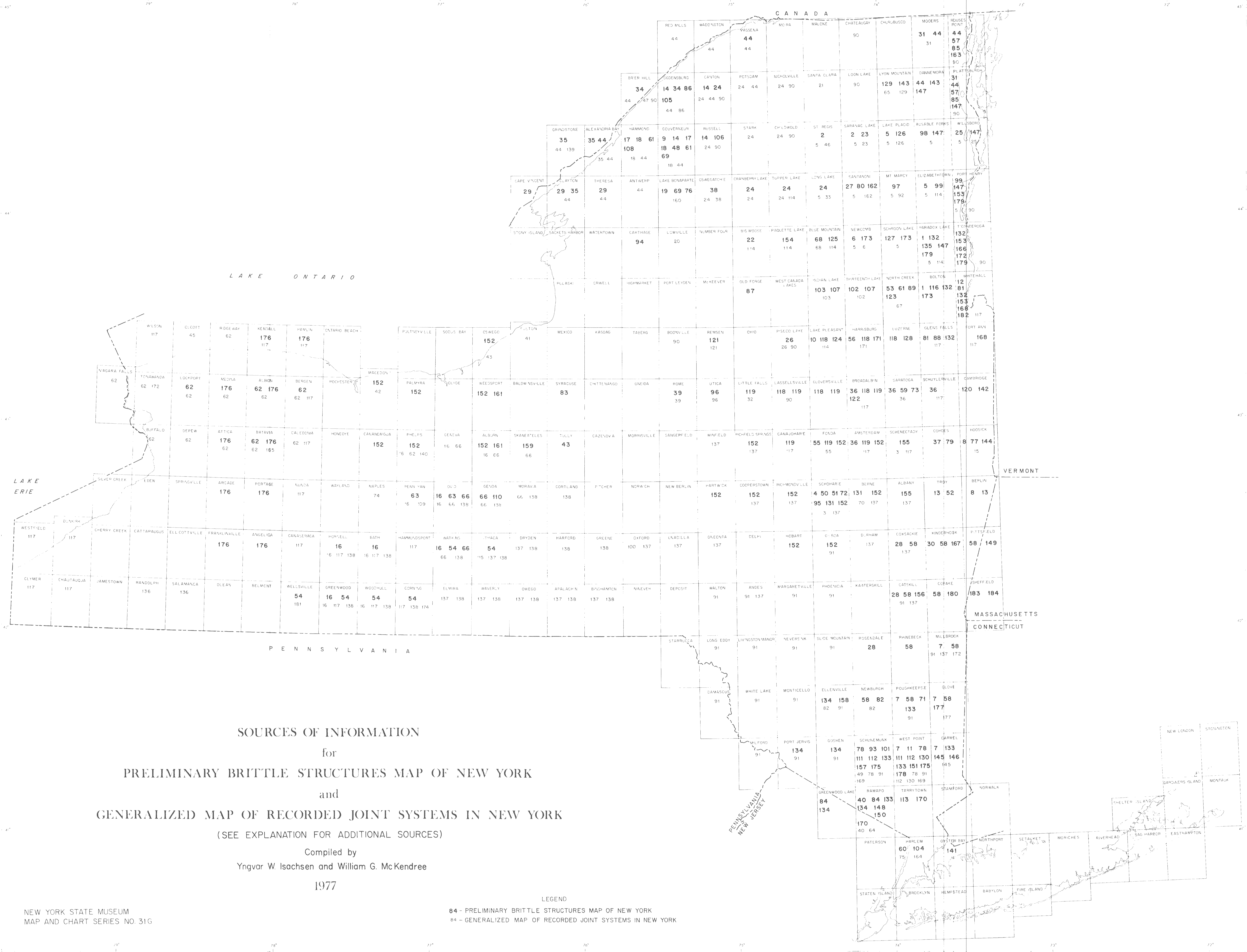

SOURCES OF INFORMATION for PRELIMINARY BRITTLE STRUCTURES MAP OF NEW YORK and GENERALIZED MAP OF RECORDED JOINT SYSTEMS IN NEW YORK

(SEE EXPLANATION FOR ADDITIONAL SOURCES)

Compiled by
Yngvar W Isachsen and William G. McKendree

1977

NEW YORK STATE MUSEUM
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LEGEND
84 - PRELIMINARY BRITTLE STRUCTURES MAP OF NEW YORK
84 - GENERALIZED MAP OF RECORDED JOINT SYSTEMS IN NEW YORK

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