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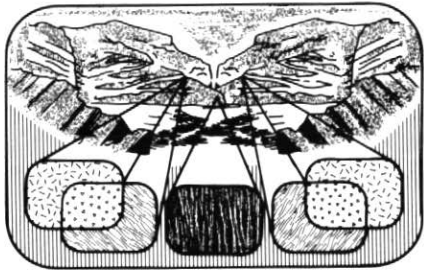
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Stratigraphic Commission

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Note 45: Need for amendment of several parts of the Code (Amer. Com. Stratigraphic Nomenclature, 1970) to provide further guidelines concerning formal terminology for intrusive igneous and high-grade metamorphic rocks. Prepared for the American Commission on Stratigraphic Nomenclature by an *ad hoc* committee on formal stratigraphic terminology for igneous and metamorphic rocks.

This "Application for Amendment" (see Article 41 of Code of Stratigraphic Nomenclature) was accepted for publication without endorsement by the Commission at the October 1975 annual meeting; comments and discussion are invited. They should be sent directly to the Chairman, ACSN, Dr. Norman F. Sohl.

Reports of the Commission express recommendations on stratigraphic practice endorsed by the Commission as of the date of publication. Notes are proposals and recommendations to the Commission and present data that bear

on problems under study; they are presented for general consideration without endorsement. Notes published by the American Commission shall include the minutes of the annual meetings. Discussions are freely contributed comments on Reports and Notes.

Free copies of Commission Reports, Notes, and Discussions may be obtained on request to the Executive Secretary, The Geological Society of America, 3300 Penrose Place, Boulder, Colorado 80301, USA.

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The members of the *ad hoc* committee acknowledge the contribution made by many geologists consulted both prior to the formulation of this proposed amendment and after an initial draft was circulated. Special mention is due several geologists of the US Geological Survey's Denver office, particularly Ogden Tweto, Paul Sims, and Robert Moench, who contributed many ideas to an early draft that formed the basis of the amendment, and to Roger Macqueen of the Geological Survey of Canada who was closely involved with the deliberations of the committee.

The Code of Stratigraphic Nomenclature recommends procedures to be followed in the formal definition of stratigraphic units. Both the concepts and the procedures it embodies are applicable to most rock types, although these concepts and procedures evolved from principles

developed primarily in studies of sedimentary rocks and their enclosed fossils. The concepts, procedures, and terminology, in large measure, can and should, be applied to volcanic rocks, and to low-grade metamorphic equivalents of both volcanic and sedimentary rocks (defined for this purpose as those rocks in which the original features are recognizable). The Code, however, has recommended that its terminology be applied to *all* rocks types (Article 1), and this has presented special problems to those working with intrusive igneous and high-grade metamorphic rocks.

Some problems in applying the terminology of the Code to intrusive igneous rocks are best illustrated by an example. The name "Tuolumne intrusive series" (Calkins, 1930) is not acceptable under the Code as a formal name; "series" is reserved for a time-stratigraphic term (Article 9f) and "group" or "supergroup" are recommended terms for formally named rock-stratigraphic units. Adjectival qualifiers are discouraged in the Code (Article 10), so the proper name by the recommendations of the Code is Tuolumne Group. By following the Code procedures, all indication that the rock bodies are something other than sedimentary or stratiform is lost. In addition, a formally named group must consist of two or more formally named formations, or for some reconnaissance work, of a unit which is divisible into formations but has not yet been divided. The major rock bodies, such as the Sentinel Granodiorite and the Half Dome Quartz Monzonite (Calkins, 1930), have been given formal names and can be thought of as formations in a group. But if such a group is given a formal name, then *all* rock bodies in the group must belong to formal formations, resulting in a proliferation of names not only unwanted but relatively meaningless to the geology of the region.

Similar problems are evident in applying the terminology of the Code to high-grade metamorphic rocks. According to the Code, if an assemblage of diverse types of schists and gneisses is called a group, the group must consist of formally named formations. To comply with the Code, enormous mixtures of grossly heterogeneous rocks have been designated formations. Such action then allows some units within the formation to be formally named as members but does not require that all be named, thereby avoiding the proliferation of unwanted names. The Idaho Springs Formation, for example, consists not only of metamorphosed sedimentary, intrusive, and volcanic rocks but also, in places, of unmetamorphosed "intrusive" rocks, migmatites, and many gneisses of uncertain genesis. Contacts between lithologic units are both conformable and cross-cutting, some are highly irregular, and the same lithology is found repeated in rock bodies of various shapes and sizes. Similar examples are abundant in the Canadian Shield. For example, in the Grenville Province (Wynne-Edwards, 1972), the original Grenville Series, later renamed the Grenville Group and more recently the Grenville Supergroup in an effort to comply with recommendations of the Code, is exposed over 800 miles across the Province. Rock-stratigraphic nomenclature procedures recommended by the Code are easily applied to those rock bodies of the Grenville that have undergone only low-grade metamorphism and retain their primary structures. In many areas, however, these rocks are completely deformed and have been intensely metamorphosed to granulite facies. Such rock masses cannot meaningfully be described or analyzed using the stratiform concepts embodied in the rock-stratigraphic terms of the present Code.

Recognizing that these rock bodies are different from those normally described by the available stratigraphic nomenclature, a proposal made here is to use the term "suite" to designate rock masses of diverse types which are either of intrusive igneous or high-grade metamorphic origin. The term "intrusive" or "metamorphic" is to be used as an adjectival qualifier to distinguish between the two kinds of suites, as, for example, Tuolumne

Intrusive Suite. In terms of rank, "suite" is to be equivalent to "group" in stratiform rock-stratigraphic terminology. A suite, however, need not have formally named divisions of formational rank.

Recommended procedures for naming units equivalent in rank to formation or member would remain unchanged. Thus the Idaho Springs Metamorphic Suite could consist in part of the following:

Idaho Springs Metamorphic Suite
 Central City Gneiss
 Biotite-quartz-plagioclase gneiss
 Biotite-sillimanite schist
 Granite gneiss and pegmatite
 Biotite schist
 Black Canyon Schist
 Pegmatite
 Amphibolite
 Coal Creek Quartzite

Some metamorphic terrains contain unmetamorphosed intrusive igneous bodies that have not been, or cannot be, mapped separately for a variety of reasons. Similarly many intrusive rock bodies contain significant volumes of metamorphic rock in the form of roof pendants or supracrustal screens between plutonic lobes that may not be practically separated from the dominant rock unit. In situations such as these, it is proposed that the term "complex" be used with the appropriate adjectival qualifier to indicate the dominant component. An example would be the Shuswap Metamorphic Complex (Wheeler, 1970).

The use of these terms (Suite, Complex) in formal stratigraphic nomenclature would not preclude their use (suite, complex) as general or informal terms.

Incorporation of the terminology for igneous intrusive and high-grade metamorphic rocks as suggested above would require the following revisions and additions to the Code:

Article 4 (j) *Lithologic units that commonly are not strata.* Many intrusive igneous rocks and high-grade metamorphic rocks are non-stratiform. Although the general principles and concepts of this Code are easily applied to most rocks, they may be difficult or impossible to apply to large nonstratiform bodies. For this reason, guidelines are offered for application of a more suitable terminology (Art. 6h, i, j; 9f, g; 10i, j; 13). Where the recommendations for rock-stratigraphic units do not specifically mention intrusive igneous or high-grade

metamorphic rocks, but nevertheless are broadly applicable to them, the intent of those recommendations should be followed (see Articles 5 through 17).

Article 6 (h) *Intrusive igneous and high-grade metamorphic rock.* Units composed of intrusive igneous and high-grade metamorphic rock that are discriminated by mineralogic or textural characteristics, or chemical composition, may be considered as equivalent to formations but the term "formation" should not be part of the formal name (see Article 10i).

Article 6 (i) *Metamorphic rock.* Formations composed of low-grade metamorphic rock (defined for this purpose as rock in which original features are clearly recognizable) are, like sedimentary formations, distinguished primarily by lithologic characteristics. The mineral facies may differ from place to place, but these variations do not necessarily require definition of a new formation (see Articles 9f and 10j).

Article 6 (j) *Complex.* If an assemblage of rock is composed of diverse types of two or more classes (i.e., igneous, sedimentary, or metamorphic rocks) with or without highly complicated structure, or of structurally complex mixtures of diverse rock types of one class, the term "complex" may be used as part of the formal name instead of the lithologic or rank term; for example, Crooks Complex. Where the rock mass is composed of diverse types of a single class of rock, as in many terrains that expose a variety of either igneous intrusive or high-grade metamorphic rocks, the term "intrusive suite" or "metamorphic suite" should be used rather than complex (see Articles 9g and 10i, j).

Article 9 (f) *Misuse of "series" for group or supergroup.* The term "series" has been employed for an assemblage of formations or an assemblage of formations and groups, especially in the Precambrian, but should no longer be so used. These are groups or supergroups. The term "series" also has been applied to a sequence of rocks resulting from a succession of eruptions or intrusions. In this usage "series" is usually preceded by an adjective such as eruptive, intrusive, or volcanic to indicate the origin of the rock. Here another term should be used; group should replace "series" for volcanic and low-grade

metamorphic rocks, and "intrusive suite" or "metamorphic suite" should replace "series" for intrusive and high-grade metamorphic rocks of group rank. (See Article 9g, 10i and j).

Article 9 (g) *Intrusive igneous and high-grade metamorphic rocks.* The term equivalent to "group" from intrusive igneous rock is "intrusive suite". An intrusive suite consists of two or more intrusive igneous rock units of formational rank, not all of which need be formally named (see Article 10i). For example the Blachford Lake Intrusive Suite may consist of the Caribou Lake Granodiorite, the Francois Bay Syenite, and the Grace Lake Granite, as well as several other unnamed (informal) intrusive units. "Metamorphic suite" is the analogous term for use in high-grade metamorphic terrains and similarly consists of two or more metamorphic rock units of formational rank. Again not all the units in a metamorphic suite need be formally named (see Article 10j). For example in the Colorado Front Range the Central City Gneiss, the Black Canyon Schist, and the Coal Creek Quartzite are formations which, together with several other unnamed gneisses and amphibolites, form the Idaho Springs Metamorphic Suite.

Some metamorphic terrains contain unmetamorphosed intrusive igneous bodies that have not been, or cannot be, mapped separately. Similarly many intrusive rock bodies contain significant amounts of metamorphic rock, in the form of roof pendants or supracrustal screens between plutonic lobes, that may not be practically separated from the dominant rock unit. In such situations the term "complex" should be used instead of "suite" with the appropriate adjectival qualifier to indicate the dominant component (see Article 6j). An example would be the Shuswap Metamorphic Complex.

Article 10 (i) *Intrusive igneous rock.* In some areas, formal stratigraphic terminology is needed for intrusive igneous rocks (see Article 6h). The formal name of an intrusive rock body of formational rank properly consists of a geographic term and the lithologic name of the dominant rock type; for example, Goose Lake Granodiorite. "Dike", "stock", "pluton", "batholith", and other similar terms are not stratigraphic terms: accordingly the names of such intrusive igneous bodies as the Idaho batholith or the Loon Lake pluton are not

stratigraphic names. Where several intrusive bodies form a larger unit approximately equivalent in rank to a "group" in standard rock-stratigraphic terminology, the term "intrusive suite" or, if applicable, "intrusive complex" (see Article 9g) is recommended, such as the Tuolumne Intrusive Suite (rather than the Tuolumne intrusive series). In contrast to the standard group (Article 9a), every part of an intrusive suite or complex need not be assigned to a formation. On the contrary, only the more uniform and larger intrusive bodies should be named, to minimize the proliferation of unneeded names. The use of the capitalized terms "Suite" and "Complex" in formal stratigraphic nomenclature does not preclude their informal use (suite and complex).

Article 10 (j) *Metamorphic rock* recognized as a normal stratified sequence, commonly low-grade meta-volcanic or meta-sedimentary rocks, should be assigned to named groups, formations, and members, such as the Deception Rhyolite, a formation of the Ash Creek Group, or the Bonner Quartzite, a formation of the Missoula Group. High-grade metamorphic rocks which cannot be correlated readily with stratigraphic units at a lower metamorphic grade should be assigned to suites or complexes (instead of groups; see Article 9g), and prominent parts may be assigned to formations and, if desired, to members.

Article 13 *Remarks (a) Specific requirements.* The proposed unit should be described and defined so clearly that any subsequent worker can, without doubt, recognize the same unit. The intent to introduce a new name and the important facts that led to the discrimination of the unit should be clearly stated. The definition should cite the geographic feature from which the name is taken.

1) Rock-stratigraphic units. The definition should cite, also, the specific location of one or more representative sections near the geographic feature. One of these sections should be designated the type section, and its description should be included. An accurate map showing the location of the type section is desirable. Where necessary, reference sections may be designated to supplement the type section, or, when the type section is no longer exposed, a principal reference section should be established. (See

remark i.) The morphological expression of the unit should be described. In defining the boundaries of a unit, it is not sufficient merely to state that the top of the X Formation is the base of the Y Formation; the criteria used in drawing the boundary should be discussed explicitly, where possible with reference to specific points in the type section or in typical sections.

2) Intrusive igneous and high-grade metamorphic rocks. The definition of a suite or complex should cite a type area with the general geographic limits of the area stated and, if applicable, a type section illustrating the diverse rock types involved. A map showing the location of this type area is desirable. Several reference localities and/or sections should also be designated within the type area to illustrate the major types of various components within the suite or complex. If a type locality should become no longer exposed, a principal reference locality should be established to replace it. The criteria used in drawing the boundaries of the unit should be described as fully as possible. Formally named rock bodies of a suite, equivalent in rank to formation, should be defined and described, and should include a type locality in accordance with established procedures for rock-stratigraphic units (Article 13a (i)).

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Workshop on Environmental Aspects of Fundy Tidal Power

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"How many major engineering projects have run into serious opposition, or been halted, or failed to meet their objectives because the planners under-estimated the real or perceived impact on society and the economy?" This rhetorical question was the beginning of one of 20 background reports and papers presented at the Workshop on Environmental Aspects of Fundy Tidal Power held at Acadia University on November 4 and 5, 1976. The workshop,

hosted by the Acadia University Institute, and sponsored by the Bay of Fundy Tidal Power Review Board, invited 120 scientists, engineers, and consultants to discuss progress reports, background papers and the results of scientific investigations concerning the environment and the feasibility of developing electrical energy from the tides of the Bay of Fundy.

The five sessions of the workshop were organized to provide initially, some background information, then to move toward the development of a consensus on the priority concerns of environmental impact for a major development scheme. In the first session members of the Management Committee of the Bay of Fundy Tidal Power Review Board reported progress on Phase I of the study program which is designed to reassess the feasibility of tidal energy previously reported by the 1969 Atlantic Tidal Power Programming Board. Within this study program five task areas are identified as: i) tidal power plant design, ii) tidal power generation, iii) systems studies, markets, alternative generation supplies and transmission, iv) socio-economic aspects, and v) environmental aspects. The last four sessions of the workshop were devoted to the environmental aspects especially as these pertained to the prime development sites located in Shepody Bay, Cumberland Basin and Minas Basin (Fig. 1).

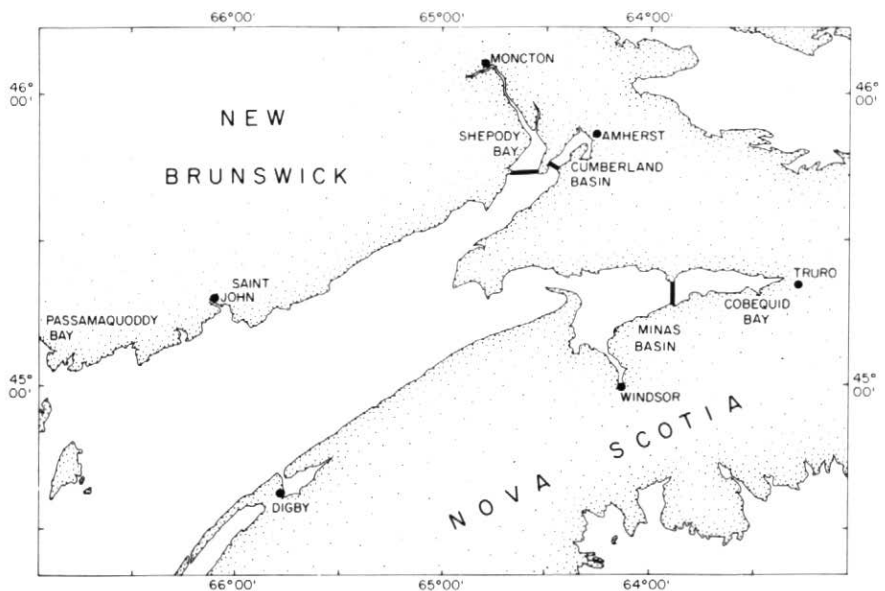


Figure 1
 Bay of Fundy and surrounding area. The primary sites for construction of tidal power

barrages are shown in Shepody Bay, Cumberland Basin and Minas Basin.