INTERNATIONAL TECTONIC DICTIONARY
ENGLISH TERMINOLOGY

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INTERNATIONAL TECTONIC DICTIONARY

ENGLISH TERMINOLOGY

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FOREWORD

The American Association of Petroleum Geologists through the years has sponsored many special publications covering broad topical areas of interest to the membership. Among these are three volumes dealing with the structure of American oil fields. The [illegible] ***not only as applied scientifically to individual*** [illegible], but also as related to broad structural problems—prompted Grover A. Murray, during his tenure as president of the Association, to appoint a committee to review the problem of structural nomenclature.

This committee decided that there was need for a dictionary of structural terms, but that no attempt should be made to prepare a geographical listing of known structural features. The committee also thought that its efforts should be limited primarily to English-language terminology.

The committee then learned that a very similar project was under way, directed by Dr. John G. Dennis of California State College at Long Beach. The project is entitled "International Geological Congress—Commission for the Geological Map of the World—International Tectonic Dictionary—English Terminology." This project was financed principally by National Science Foundation Grant No. GP 2101.

The Committee on Structural Nomenclature of the Association recommended that it not duplicate the efforts of Dr. Dennis. The committee reviewed the manuscript and made many suggestions but did not act as a critical editorial board.

The present volume represents a cooperative scientific effort by the International Geological Congress, the National Science Foundation, and The American Association of Petroleum Geologists. The committee believes that publication of the volume will be a step forward in the field of structural geology, and that it will provide the necessary stimulus for further refinement of structural terms. The committee also believes that the dictionary will be useful to the profession of petroleum geology, as well as to the science of geology generally.

This dictionary will be a worthy companion to a long series of special volumes that the Association has sponsored.

Respectfully submitted,

COMMITTEE ON STRUCTURAL NOMENCLATURE
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INTRODUCTION

Purpose: Scientific terms are supposed to differ from the words and expressions of everyday language in that they are precisely defined and carry a fixed connotation, almost like mathematical symbols. If this were so in geology, it would be safe to say that at least half of all existing and historical controversies would never have arisen. However, geologic, and particularly tectonic, terminology suffers from a multitude of semantic inconsistencies which hamper communication between geologists and other scientists, between geologists of different languages, and between geologists of the same language.

The International Tectonic Dictionary of the Commission for the Geological Map of the World seeks to alleviate this situation for the languages of the International Geological Congress. This dictionary of English terminology is the first to be published. Dictionaries of French, German, and Russian tectonic terms are being prepared by national committees. In addition, a multi-language dictionary of tectonic terms, giving annotations and equivalences in English, French, German, and Russian, is being compiled by the Commission for the Geological Map of the World under the editorship of the Secretary General, and with the collaboration of the national groups concerned. It is hoped that Italian and Spanish will eventually be added. (English, French, German, Italian, Russian, and Spanish are the official languages of the International Geological Congress.)

The function of this compilation is to provide a guide to past and current usage, and to make recommendations where current usage is ambiguous or might lead to misunderstandings. An important fundamental principle in tectonics requires that descriptive terminology and genetic terminology be kept rigidly apart. Terms and expressions used in observation and description must not carry any genetic connotation or implication, directly or indirectly. Genetic terms should be used only for explicitly evaluating or interpreting observations The concept behind a term should be fully understood by all who use it.

The editor trusts that this work is free from error, but, in an undertaking of this nature, freedom from error may be an unrealistic hope. Any corrections, suggestions, and other information which will help to make this, and the multi-language dictionary, more useful to geologists and to others will be welcomed.

Scope: This compilation is restricted in scope—it contains most commonly used tectonic terms, and some uncommon ones. Because time was limited, the number of terms that could be included was limited. Recently proposed genetic terms which are fully described in original published work were normally excluded as a matter of policy. However, some less common terms that could be annotated readily without much expenditure of time have been included. Many selections are, of necessity, arbitrary. Suggestions for later editions are invited.

Organization: Each annotation has several subheadings. As a rule, these are: ***Derivation, Definition, History and usage, Synonyms,*** and (or) ***Related terms.*** However, a rigidly consistent scheme was found to be unworkable, and subheadings are adapted to each annotation according to specific requirements. In many annotations, "***Explanation***" seems more apt than "***Definition.***" In others, an additional subheading, such as "***Recommendations,***" is needed. In some annotations subheadings are combined.

Under "***History and usage,***" wherever possible, the first use of the term is given. Following it, the most important examples of usage are cited to illustrate the evolution

of connotation. Originally it was intended to include only English usage, but this soon proved to be very unsatisfactory; consequently, wherever foreign usage of a term appears relevant, it is given in English translation. (The original can readily be consulted through the bibliography.) In many places recommendations are given. This was found to be desirable for various reasons; for example, where usage is conflicting, where genetic implications have become implicit in descriptive terms, and where an erroneous geometric or physical concept is implied. Inevitably, such recommendations are open to controversy, and the editor does not deny that he had preferences. However, review by a panel of recognized structural geologists with widely divergent opinions has helped to conserve a reasonably balanced outlook.

READER'S GUIDE: Not all terms have complete entries. Many are explained or defined in the body of a "parent annotation," where they are set in **SMALL-CAPITAL BOLD-FACED TYPE.** Where terms are mentioned that should be consulted under other headings, they are set in **lower-case bold-faced type**, and their main entry (either their own annotation or an explanation or definition in the body of another annotation) may be found through the index (page numbers for main entries are in bold-faced type).

Under ***"Derivation,"*** "Webster" refers to the *Webster Dictionary of the English Language*, and "O.E.D." to the *Oxford English Dictionary*.

The terms are in alphabetical order, except that "bedding," "cleavage," "dike," "fault," "fold," and "joint" terms, and named orogenies, follow those main headings. However, to locate a term it is best to use the index, as many terms do not have full annotations and are given only in the body of the annotation for another term. The index is comprehensive and thus useful for locating cross-references.

Bibliographic references are usually to pages, except where the work referred to is of the glossary type and has an alphabetical order of entries, or where a whole work is devoted to the topic concerned.

HISTORY AND ACKNOWLEDGMENTS: Between 1956 and 1960, E. Wegmann in Switzerland, A. A. Bogdanoff in the U.S.S.R., and J. G. Dennis in the United States independently took initial steps toward compilation of an international tectonic dictionary under the auspices of the International Geological Congress. The preparation of such a dictionary had become necessary because of the many misunderstandings caused by varying usage of terms, not only in different languages, but also within each language. This is particularly true of British and American usage.

At the August 24, 1960, meeting in Copenhagen of the Subcommission for the Tectonic Map of the World, International Geological Congress, it was decided to create a committee for the preparation of an international dictionary of tectonic terms in the official languages of the Congress under the auspices of the Subcommission for the Tectonic Map of the World, an organization of the Commission for the Geological Map of the World. The subcommittee for the English language in the preparatory stage included P. B. King, Menlo Park, California; E. S. Hills, Melbourne, Australia; F. Dunning, London, England; and J. G. Dennis, Long Beach, California. The subcommittee members asked Dennis to proceed with the actual task of compiling the English terminology, but continued to help in many ways. Full-time work on the project started in 1962, when the National Science Foundation, Washington, D. C., began its generous financial support which lasted into 1965. In addition, the project has benefited from a supplemental grant from the Long Beach, California State College Foundation, and a further supplemental grant for publication from the National Science Foundation. At the December, 1964, meeting in New Delhi of the Commission for the Geological Map of the

World, it was decided to make the International Tectonic Dictionary the direct responsibility of the parent commission. The project has been furthered greatly by the helpful cooperation of these bodies and their members, particularly F. Delany, Secretary General of the parent commission; A. A. Bogdanoff, Secretary of the subcommission; and present and former members of the Dictionary Committee—F. Dunning, E. S. Hills, P. B. King, H. Murawski, J. Roger, H.-J. Teschke, and E. Wegmann.

Appreciation is expressed for help given by the members of the Advisory Board, who reviewed and criticized preliminary drafts as they were being prepared, and whose influence on this compilation has been exceptionally valuable; and by the members of the Committee on Structural Nomenclature of The American Association of Petroleum Geologists and Donal M. Ragan, who reviewed the completed manuscript and who, as a result, are responsible for many important improvements. Library research was the most extensive single activity, and the project is greatly indebted to the careful work of Ruth Small, who began library work in London, and Christabel Smyth, who continued and completed it in the United States. Jessie Heitner contributed ably in the summer of 1963. Special thanks go to Norman Bueche, who drew most of the illustrations. Indebtedness is acknowledged to the following institutions and their staffs, especially the library staffs: The Geological Survey of Great Britain; Division of Geology, California Institute of Technology; Department of Geology, University of Colorado; Department of Geology, University of California at Berkeley; and the editor's home institution, California State College at Long Beach. The editor also is greatly indebted to the officers and editorial staff of The American Association of Petroleum Geologists for their untiring efforts, cooperation, and wise counsel. In addition, gratitude is expressed to the many colleagues too numerous to mention by name who have kindly provided valuable information and criticism.

JOHN G. DENNIS

INTERNATIONAL TECTONIC DICTIONARY—ENGLISH TERMINOLOGY

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ANNOTATIONS

ALLOCHTHONE, ALLOCHTHONOUS

Derivation: Greek *allos,* other; *khthon,* earth, ground.

Definition: An allochthonous rock mass or allochthone is a rock unit which has been transported from its original site of emplacement.

History and usage: (*a*) First used as an adjective to designate rocks of distant origin: *allochthone limnatische Gesteine* (Naumann, 1858, p. 657). Gümbel (1884) applies the term to coal formed by transported plant material (hence, allochthonous coal).

(*b*) At the beginning of the 20th century, the term acquired a tectonic connotation to designate rock units of varying dimensions (such as **nappes** and nappe complexes) which, as a result of tectonic transport, have come to rest on a distant substratum.

The term still is being used in sense (*a*) for transported coal and other transported residual rocks, and in sense (*b*) for transported tectonic units (*e.g.*, Kay, 1945 b, p. 440). It is, however, commonly difficult to determine whether transport has been tectonic or sedimentary, particularly in the case of very small constituents, also known as **EXOTIC** blocks (*e.g.*, in the Wildflysch). Some authors use allochthone to refer to various redeposited sedimentary materials from more or less distant sources (usage of some Italian authors). This extension of meaning should be limited.

Related terms: **Autochthone, klippe, nappe, thrust sheet.**

ANTICLINE

Derivation: Greek *anti,* against; *klinein,* to slope.

Definition: A fold with a core of stratigraphically older rocks (after Bailey, 1960, p. 33).

History and usage: The qualifier "anticlinal" was introduced by Conybeare and Buckland (1824, p. 213): ". . . lines which may be termed anticlinal lines, formed by the saddles of strata on either side of which the strata dip in opposite directions." J. Phillips (1837, p. 39) adopts the same usage, emphasizing that "anticlinal" refers to the crest line only, the complete fold being termed a "saddle." "*Anticlinal*—applies to strata which dip in opposite directions from a common ridge or axis, like the roof of a house, and [which] form what is termed an *anticline* or saddleback" (Page, 1865, p. 88). "Anticlinal" at that time was used as an adjective, but was shortened by some to the noun form "anticline," which gradually became the preferred term. Lapworth (1883, p. 199) used "anticline" as a synonym for "arch," but also used "anticlinal" (1883, Pl. 5, Fig. 10; Pl. 8, Fig. 1). B. Willis (1893, p. 219) defined an anticline as an ". . . upward convex curve, . . . older strata within domes of . . . younger." As used by Bailey and McCallien (1937) and Bailey (1960), an anticline is a fold with a core of older rocks.

Synonyms: Anticlinal (obs.), arch (in the above sense, now obs.), saddle (obs.).

Related terms: **Anticlinorium, antiform,** anticlinal (adj.), **geanticline, anticlise.**

ANTICLINORIUM

Derivation: Anticline, and Greek *oros,* mountain (Dana, 1873); anticline, and Latin *orium,* a place for (Challinor, 1964).

Definition: A composite anticline, consisting of several subsidiary folds.

History and usage: "This brings us to another important distinction in orographic geology—that of a second kind of monogenetic mountain. The *synclinoria* were *made through*

a progressing geosynclinal. Those of the second kind, here referred to, were *produced by a progressing geanticlinal.* They are simply the upward bendings in the oscillations of the earth's crust—the geanticlinal waves, and hardly require a special name. Yet, if one is desired, the term *anticlinorium,* the correlate of *synclinorium,* would be appropriate" (Dana, 1873, p. 431). Van Hise (1896a, p. 607) states: "All folds . . . when not simple, are called, following Dana, *anticlinoria* and *synclinoria.*" However, here Van Hise is *not* following Dana but is, in effect, redefining the term. Leith (1914, p. 105) follows Van Hise: "Anticlinorium and synclinorium refer to composite arches and troughs." The same usage is given by Willis and Willis (1934), and by most writers to this time.

Related terms: **Synclinorium, anticline.**

Example: Green Mountain anticlinorium, Vermont.

ANTICLISE*

Derivation: Greek *anti,* against; *klino,* incline.

Explanation: A first-order positive cratonic structure of irregular elongate or isometric outline in plan, occupying an area of tens or hundreds of thousands of square kilometers (the Volga-Urals, Belorussian anticlises). Within an anticlise the attitude of the platform cover is quaquaversal; angles of dip of the flanks, which are locally steplike, are fractions of a degree. Older strata of the platform cover, or even rocks of the folded basement, crop out in the central parts of an anticlise. The thickness of the platform cover within an anticlise is no more than several thousand meters. The sedimentary sequence of the cover of an anticlise is characterized by gaps; certain intervals are missing and sediments are coarser in comparison with sediments in adjacent syneclises. An anticlise is developed over a long period of time in the course of several geologic periods, remaining as an uplift in relation to actively sinking syneclises, or is formed as a result of active uplift of the earth's crust. In the latter case, there may be stretching, faulting, and formation of grabens (*e.g.,* the Rhine, East African grabens, *etc.*); volcanic activity is displayed within some of them (the Central Massif in France).

History and usage: The term "anticlise" was first used in 1916 by V. A. Teriayev, who treated it as a gently dipping anticlinal (arch-like) platform structure. The present meaning of the term was proposed by N. S. Shatsky (1945).

Partial synonyms: **Arch, uplift, anticlinorium.**

Related term: **Syneclise.**

ANTIFORM

Derivation: Greek *anti,* against; and form.

Definition: Fold which closes upward (after Bailey and McCallien, 1937, p. 80).

History and usage: Heim (1878, v. 2, p. 195) distinguishes between true (stratigraphic) anticlines and forms which close upward (*Sattel*). Bailey and McCallien introduced the English equivalent for *Sattel,* as defined. Used for upward-closing folded surfaces where the term "anticline" in its true stratigraphic sense cannot be applied. First American use in the above sense is in the legend of the 1961 Geological Map of New York (New York, 1962).

* This annotation was freely translated from a draft of the Russian tectonic dictionary.

Related terms: Anticline, synform.

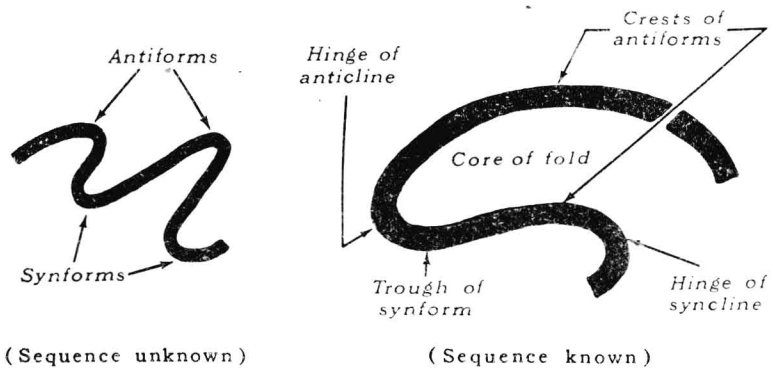

FIG. 1.—Antiforms and synforms.

ANTITHETIC

Derivation: Greek *anti,* against; *thetos,* placed; first used in German literature (H. Cloos, 1928b).

Explanation: "Antithetic" describes a system of nearly parallel normal faults with rotation of fault-bounded blocks such that the **net slip** on each fault is greater than it would be without rotation. Originally horizontal planes are tilted to dip in the direction opposite the dip of the fault (after H. Cloos, 1928b; 1936, p. 267).

Usage: Antithetic movements are smaller movements that are associated with larger movements but have the opposite tendency (after Balk, 1936a, p. 61). "[The faults] . . . have moved . . . in opposition to the general uplift; such faults have been termed antithetic . . . . For the opposite kind, faults that have moved in harmony with the general uplift, the term synthetic has been used" (P. B. King, 1948, p. 112) Mackin (1960, p. 110) writes: "If one word expresses the habit of basin-range faulting more completely than any other, it is 'antithetic,' in the sense that, regardless of the direction of the dip of the faults, their throws tend to be opposite to, and to counteract the effect of, the dip of the faulted strata."

Related terms: Synthetic, step faults.

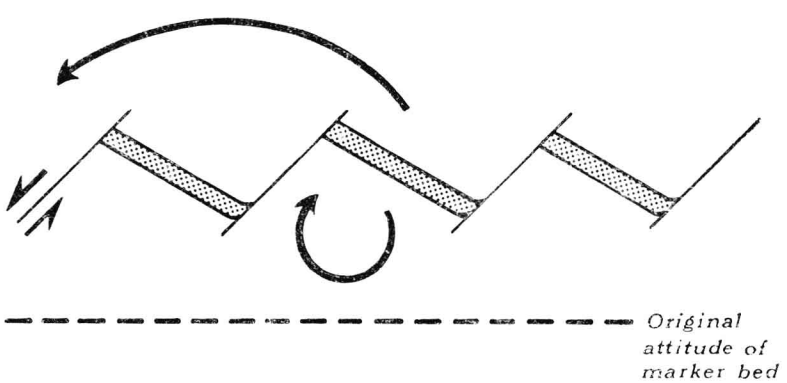

FIG. 2.—Antithetic faulting, showing sense of rotations (contrast **synthetic**).

APEX 1

Derivation: *See* **apex 2.**

Explanation: "The highest point at which the ore or rock is found in place or between the walls of the vein, and not a 'blow-out' or part of the vein broken down outside the walls. In case the vein outcrops at the surface, any portion of such outcrop is the top, or apex. If the vein does not reach the surface, then the highest point to which the vein, or lode, can be traced is the apex—not necessarily the nearest point to the surface, but the absolute highest point" (Fay, 1920).

APEX 2

Derivation: The highest or uppermost point: summit, top, peak. . . . The highest or culminating point (Webster).

Definition: Locus of greatest curvature in a given folded surface.

History and usage: ". . . the apex or most incurved part of each of the concentric flexures, . . ." (Rogers and Rogers 1843, p. 485). "The 'apex' of a fold is the line of intersection between the axial plane and either that of the horizon or the ground surface" (Busk, 1929, p. 7). "The apex [of a fold] is where the bend is sharpest" (Stočes and White, 1935, p. 114). ". . . apex is here defined as the line along which the axial plane intersects a given horizon in the fold. More directly stated, the apex is the point, in a cross-section, where the rate of change of dip is greatest, and the fold is, therefore, most acute. Along the fold, the apex is a line comprising such points" (Hills, 1953, p. 79).

Remarks: Obsolescent in the above sense; now replaced by **hinge.**

ARCH

Derivation: Curved structure supporting a bridge, floor, *etc.*, or merely ornamental; curve (O.E.D.).

Definition: A large, open, elongate anticlinal structure in any geological surface or family of surfaces.

History and usage: "The companion type of the syncline is the anticline, or arch; this is an elevation of the strata in a direction opposed to gravity, from a flat to a dome-like or semi-cigar-shaped form. The cross-section varies from a broad, gentle arch to an acute straight-sided roof" (B. Willis, 1893, p. 219). "Where strata dip away from an axis so as to form an arch or saddle, the structure is termed an anticline, . . ." (A. Geikie, 1903, p. 675). "An arch is a gentle, broad uplift with an evident width of 25 to 200 miles and a length conspicuously greater than the width. The structural relief may amount to 10,000 feet or more between a bed at the top of the arch and one of similar age at the bottom of the adjacent basin, but the dip of the beds will generally not exceed 100 feet per mile" (Eardley, 1951, p. 4). "It is found that foliation surfaces and flow lines in large intrusions commonly form a dome or arch . . . . if the flow structures are absent from the interior, and exist only around the borders, the arrangement is termed an arch" (Hills, 1953, p. 140). "Arch. A large uplift of anticlinal nature having a length considerably greater than the width. The dimensions are on the order of tens or hundreds of miles, and the breadth of crest, gently sloping flanks, and lack of well-defined axis are characteristic . . ." (Stokes and Varnes, 1955).

Remarks: Term most commonly applied to basement structures and their mantling rocks where vertical movement is inferred.

Related term: **Dome.**

Partial synonyms: **Anticline, platform, anticlise.**

Example: Cincinnati arch.

ASTHENOSPHERE

Derivation: Greek *asthenes,* weak.

Definition: Region of assumed greater yielding in the mantle. In contrast to **stereosphere.**

History and usage: Barrell (1914, p. 659) proposes the term because: "The theory of isostasy shows that below the **lithosphere** there exists in contradistinction a thick earth-shell marked by a capacity to yield readily to long-enduring strains of limited magnitude. . . . Its comparative weakness is . . . its distinctive feature. It may then be called the sphere of weakness–*the asthenosphere* . . ." Gutenberg (1955, p. 19) by implication defines asthenosphere (in contrast to **lithosphere**) as a region at depths having a yield strength of less than $10^9 \pm$ dynes/cm^2: ". . . the transition from the lithosphere to the asthenosphere is gradual, without a definite boundary." Bucher (1955, p. 344), in the same symposium, places the top of the asthenosphere at ". . . what the geodesist calls the 'level of compensation' ($\pm$100 km) . . ."

Related terms: **Lithosphere, stereosphere.**

ATTITUDE

Derivation: The posture or position of a person . . . or sometimes an inanimate object . . . (Webster).

Definition: "Attitude is the full geometric description of the orientation of a plane, conveniently expressed as strike and dip, or of a line, commonly expressed as a trend and plunge or, more rarely, as pitch in a given plane" (Oertel, 1962, p. 326).

History and usage: "To define the attitude of the side of a fold it is usual to give the strike and dip of a stratum of the fold; that is, the azimuth of a level line drawn on the stratum and the angle between a line drawn at right angles to this and a horizontal plane" (B. Willis, 1893, p. 220). This geometric definition of attitude was accepted first in North America and later in other English-speaking countries. In Britain an alternative, more general connotation persists: "Attitude. The disposition or posture of a rock-body, structural unit, or structural element. Thus a succession of strata may be the right way up (either horizontal or dipping), vertical, or inverted; a fold may be in the normal position, be recumbent, or be overturned; a fault has an attitude with regard to its dip and also a separate one, normal or reversed, with regard to the displacement of strata" (Challinor, 1962).

Related terms: **Dip, strike, trend, plunge.**

Note: The attitude of a plane may be expressed also as dip and dip direction (*e.g.,* Landes, 1958). This is helpful in reducing errors, and is a more suitable form for processing of the readings statistically.

AUTOCHTHONE, AUTOCHTHONOUS

Derivation: Greek *autos*, the same; *khthon*, earth, ground.

Definition: An autochthonous rock mass or autochthone is a rock unit which has not been transported from its original site of emplacement.

History and usage: (*a*) First used as an adjective to designate rock units localized at the site of their original emplacement or formation: *autochthone limnatische Gesteine* (Naumann, 1858, v. 1, p. 657). Gümbel (1884, p. 111-216) applies the term to coal forming or formed in place (hence, autochthonous coal).

(*b*) At the beginning of the 20th century, the term acquired a tectonic connotation to designate rock units underlying **allochthonous** units, and which have not themselves undergone tectonic transport (Lugeon, 1902, p. 794 and Fig. 11). Alpine massifs such as the Pelvoux, Montblanc, Aare, and Gotthard massifs are considered autochthonous.

The term is used in sense (*a*) for coal and other residual rocks, and in sense (*b*) in tectonics.

Related terms: **Allochthone, nappe.**

AXIAL CULMINATION

Derivation: Latin *culmen*, highest point, summit.

Definition: Topographically highest point on any **axial line** in a fold.

History: Concept introduced by Rogers and Rogers (1843, p. 491): "Culminating portion of the axis . . . where along the length of the axis the lowest beds are brought up by an upward bend of the axis itself." So used since then, especially in Alpine tectonics: "[Culmination is] . . . applied to the pitch of folds [and thus to nappes] for the position where the crown-line reaches its greatest elevation. From such a culmination nappes may fall away in all directions. Many of the great windows of the Alps are formed by the erosion of nappe culminations and thus reveal the domed back of a lower nappe, or the autochthon" (Boswell, 1929, p. xxii).

Partial synonyms: Restricted meanings of the following: **dome, pericline.**

Related term: **AXIAL DEPRESSION:** the topographically lowest region or point on an **axial line.**

Example: Axial culmination of the Pennine nappes in the Tessin.

AXIAL PLANE

Definition: The family of penetrative planar fabric elements defined by the **fabric axes** *a* and *b* extrapolated over a given domain (following Oertel, 1962, p. 338).

Usage: Concept formulated by Oertel (1962, p. 338-339) to express the symmetry of penetrative planar fabric elements, and derived from the original concept of discrete axial surfaces. Axial planes may be curved (curviplanar). Formerly used synonymously with **axial surface.**

Related terms: **Axial surface, plane.**

AXIAL SURFACE, AXIAL HINGE SURFACE

Definition: Surface which contains all the hinge lines, or some other specified family of stacked lines in a fold (*e.g.*, crest lines, subsidiary fold hinges).

History: "The axis plane [extends] through the apex or most incurved part of each of the concentric flexures, so as to occupy a medial position between the two branches of the curve" (Rogers and Rogers, 1843, p. 485). The definition remains valid, but the second part, referring to "medial position" is not necessarily true. Rogers (1856, p. 435) redefines "axial plane" in different words, but in the same sense. De Margerie and Heim (1888, p. 53) define "axis or axial plane" as the plane of symmetry which lies along the bisectrix of the acute angle formed by the two opposite limbs of the fold. This definition, though erroneous, is repeated by many authors. Wilckens (1912, p. 9) distinguishes between the "median surface" (*Mittelebene*), *i.e.*, the surface which bisects the angle between the **limbs**, and the true axial surface (*Achsenebene*) in the sense of the above definition. Bonte (1945, p. 35) conforms to Rogers and Rogers' (1843) original definition. Oertel (1962, p. 338) gives a precise geometric formulation, and distinguishes the **penetrative** family of **axial planes** from **discrete** axial surfaces.

Synonyms: Axial plane (obs.), apical plane (obs.).

Related terms: **Axis (of folding), axial plane.**

Diagram: See Figure 16 under **fold.**

AXIAL TRACE

Derivation: Trace: intersection of two surfaces or sets of surfaces.

Definition: "The intersection of the axial surface of a fold with the topographic surface or any other specified surface" (Howell *et al.*, 1957).

Remarks: The AGI glossary of geology (Howell *et al.*, 1957) notes that the common **use** of the term "axis" for this feature is incorrect. Actually, "axial trace" is a potentially misleading term, and might be avoided in favor of such terms as "map trace of the axial surface" or "trace of the axial surface on . . ."

Related term: **Axial surface.**

AXIS (of folding)

Derivation: Latin *axis*, a pole or axle tree.—The straight line about which the parts of a body or system are symmetrically arranged, or round which a body rotates. A centered ridge, the central line of a valley (O.E.D.).

Definition: The nearest approximation to the line which, moved parallel with itself in space along a curved path, generates the fold, or any cylindrical portion of it (after Wegmann, 1929; McIntyre, 1950).

History and usage: Playfair (1802), describing folded rocks, observed: "Sections of the bent strata by a horizontal plane are straight lines parallel to one another. On this account every such stratum seems as if it were bent over an axis, and the axes of all these different bendings, for a great extent of country, are very nearly parallel." On the other hand, Sedgwick and Murchison (1832, p. 303) refer to ". . . an axis of primary . . . rocks, flanked . . . by two great secondary zones." J. Phillips (1837, p. 39) describes an anticlinical axis as ". . . a certain straight line, so that the rocks decline from it on both sides." Rogers (1856, p. 435) goes back to Playfair's original usage, referring to ". . . the horizontal lines or axes round which the individual concentric strata have been bent in the act of . . . folding." However, later (1858, p. 1025) he helps to create the confusion which has surrounded the term: "AXIS . . . Signifies in geology the line of sharpest

bending, whether convex or concave, of a stratum. The Anticlinal Axis is equivalent to the crest of the convex wave; the Synclinal Axis to the line of greatest depth in a trough or concave wave." Another usage was introduced by Lapworth (1883): ". . . alternate arches and troughs whose axes are vertical and beds dip in opposite directions." Similarly, de Margerie and Heim (1888, p. 53) state: "The *axis* or rather *axial plane* of a fold is the plane of symmetry following the bisectrix of the angle formed by the limbs of the fold." Dana (1896, p. 101) and later Hills (1940) use axis as the trace of the axial plane on a transverse section. Willis and Willis (1929, p. 30) describe the axis as the crest or trough line of a fold.

Modern usage agrees with Wegmann's definition given above (see especially R. Clark and McIntyre, 1951a, p. 594-597; also Wilson, 1961; Challinor, 1961), which is the sense in which the term has been used by European, especially Alpine, geologists since the 1890s, and which was anticipated by Playfair when he first used the term.

Remarks: The fold axis is a direction of reference in space; it is penetrative and *not* a discrete line that can be placed on a map.

Synonyms: AXIAL DIRECTION (components: axial trend, axial plunge). LONGITUDINAL AXIS (Hill, 1963), FOLD AXIS.

Derived terms: Axial plane, axial surface, axial trace. AXIAL LINE: a straight discrete line of unique geometrical significance (Oertel, 1962, p. 326). AXIAL CURVE: a curved discrete line of unique geometrical significance (Oertel, 1962, p. 326).

BANDING

Derivation: A thin flat strip of any material (Webster).

Definition: An outcrop feature, developed in many rocks, due to the alternation of layers which differ conspicuously in mineral composition or texture or both (modified from Holmes, 1928).

History and usage: Payne (1942, p. 1724) states that ". . . the term band is applied to a **stratum** or lamina, conspicuous because it differs in color from adjacent **layers**; a group of layers displaying color differences is described as being 'banded'." Howell *et al.* (1957) describe banded texture as ". . . the texture of rocks having thin and nearly parallel bands of different textures, colors or minerals." Challinor (1961) classifies "banding" into three groups: (1) In strata, thin, conspicuous bedding. (2) In igneous rocks, flow banding (or any other kind of banding) in lavas or intrusions. (3) In metamorphic rocks, foliation (including gneissic structure) or mylonite banding. He gives layering and stratification as synonyms.

Remarks: Banding properly refers to appearance in outcrop, not to rock structure or fabric, because a band is continuous in only one dimension, but a **layer** is continuous in two dimensions.

BASEMENT

Derivation: Greek *basis*, the lower or basal part of anything.

Definition: A large segment of rocks that have undergone regional metamorphism, granitization, intrusion, or intense deformation and are mostly overlain by unmetamorphosed rocks.

History and usage: The term, it seems, first appeared in print in 1896: "The study of the Archaean rocks has difficulties, but not so great as are implied in the term 'Basement

Complex,' sometimes used for the more crystalline kinds . . ."; (Dana, 1896, p. 458). "Those who believe in the clastic origin of the Archaean . . . will not question the conclusion reached as to the age of the Basement Complex. . . . the oldest group of rocks of which we have any knowledge . . . is often called the Basement Complex" (Van Hise, 1896a, p. 747). Daly (1951, p. 25) states: ". . . the word *Basement* is here used in a relative sense and refers only to the visible or clearly inferable part of the foundation on which the veneer [of younger rocks] rests." The wider definition given above has come to be generally accepted (*e.g.*, H. Cloos, 1948a,b). Note, however, Howie and Cumming's statement (1963, p. 1): "For the purpose of this study, the basement rocks are defined as those rocks that are of undoubted Precambrian age, together with igneous and metamorphic rocks, which are as yet not stratigraphically dated, and unstudied low-grade metamorphic complexes." According to P. B. King (1964, p. 11), ". . . parts of the continents . . . are covered by flat-lying or gently tilted deposits, mainly sedimentary, which are underlain at varying depths by a basement of rocks that had been consolidated not only by earlier deformations, but in part by metamorphism and plutonism."

Remarks: Locally, "basement" may refer to rocks underlying any pronounced unconformity, especially where post-basement rocks have become better known geologically, as in some oil and coal fields. It is then a relative term.

Related terms: **Platform, craton, shield. Cover:** the rocks overlying the basement.

Example: Paleozoic basement underlying the London basin.

BASIN

Derivation: Latin *bachinus*, round vessel.—Round vessel, less deep than wide and narrowing downward (O.E.D.).

Definition: Strata dipping toward a common center (D. Page, 1865). Upwardly concave flexure in which the dip is toward the center from all directions (E. Hills, 1953).

History and usage: "When . . . strata decline upon every side toward a certain point, they are said to be basin-shaped" (Greenough, 1819, quoted by Challinor, 1961). "'BASIN' of Paris, 'BASIN' of London. Deposits lying in a hollow or trough, formed of older rocks, sometimes used in geology almost synonymously with 'formations' to express the deposits lying in a certain cavity or depression in older rocks" (Lyell, 1835, v. 4, p. 317-318). Thus Lyell emphasizes basin content rather than basin form. "BASIN.—A concave or trough-like form in a set of strata; sometimes applied to very wide areas, in which the strata are centrally horizontal, and rise to the surface only at the margin" (H. Rogers, 1858, p. 1025). "Opinions differ widely regarding the application of the names geosyncline, trough and basin" (Umbgrove, 1947, p. 342). De Sitter (1956) and Fairbridge (1957) use basin (non-folded) as opposed to **geosyncline** (folded).

Remarks: Any implicit restriction on the term "basin" limiting its purely descriptive general sense is apt to introduce misunderstandings. Restrictions should be explicit (*e.g.*, sedimentary basin, cratonic basin). A basin is generally understood to be more or less equidimensional in plan, with gentle dips, as opposed to a **marginal trough**, which is understood to be elongate, with less gently sloping sides.

Related terms: **Sedimentary basin:** basin formation preceded or kept pace with sedimentation. **Structural basin:** basin shape was acquired mainly after deposition of strata forming basin. **Physiographic basin:** basin-shaped relief feature. Several derived and related terms are given by Umbgrove (1947, p. 44-45) and Kay (1951). **Depocenter:**