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SEDIMENTOLOGY

GENERAL INTRODUCTION AND DEFINITIONS

Fluvial Sediment and Channel Morphology

By Roger G. Wolff and Paul C. Benedict

Prepared by Quality of Water Branch
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INTRODUCTION

Sedimentology, the study of sedimentary rocks and the processes by which they are formed, includes and is related to a large number of phenomena. Sedimentology includes the five fundamental processes defined by the term sedimentation --weathering, erosion, transportation, deposition and diagenesis.

Sedimentology shares with geomorphology the study of the surface features of the earth. Sedimentology also shares with hydrology the study of river channels. River channels are formed in part or in total as a result of flowing water and sediment transport, commonly called the "work of the rivers."

This survey of published literature was made to aid in arriving at definitions which would be acceptable to, and representative of, a majority of professional personnel actively engaged in laboratory and field investigations related to the "work of the river." The definitions in this list are intended to explain the terms used in studies of fluvial sediment and channel morphology. No set of definitions can expect universal acceptance, however, it is hoped that this compilation will be considered a summary and synthesis of present and past usage and that it will serve as a starting point for future usage.

Multiple references are cited from textbooks, glossaries and dictionaries, scientific journals and U.S. Government publications. To obtain a mutual understanding and enhance precision, many of the proposed definitions are a composite of those selected from papers or reports covering research studies and field investigations.

A draft of this glossary has been reviewed by a group of interested personnel. The results of this review have been carefully considered and the originally-suggested definitions have been revised accordingly, resulting in the present compilation.

R. G. Wolff, with the help of Mrs. V. Blatcher, carried out the literature search and compilation of terms and the review results. Paul C. Benedict approved or composed the definitions as presented in this report.

GEOMORPHOLOGY

Proposed Definition

Geomorphology.--That branch of science concerned with the land forms of the earth, their nature, origin and development; and the processes acting upon them.

Discussion

Geomorphology or physiography--preference for and usage of these two terms is not universal:

> Thornbury (Principles of geomorphology, 1954) discredits "physiography" because of its European usage where it includes climatology, meteorology, oceanography and mathematical geography.
>
> Twenhofel (Principles of sedimentation, 1950) discusses the "physiographic cycle" with no mention of "geomorphology."
>
> Trask (Applied sedimentation, 1950) uses both terms.
>
> Krumbein and Sloss (Stratigraphy and sedimentation, 1951) refer only to "geomorphology."
>
> Leopold and Maddock (U.S. Geol Survey Prof. Paper 252, 1953) define and use "geomorphology."

Based on: (1) the apparent preference of recent American investigators for "geomorphology"; (2) the meaning of the Greek roots (a discourse on earth forms); and (3) the use of "geomorphology" to connote a study of the processes involved in land forms as well as the role played by the geology of the area; geomorphology will be used in this report.

Glossaries and Dictionaries

"Geomorphology. 1. 'The systematic examination of land forms and their interpretation as records of geologic history introduces a new branch of geologic science, called "physical geography" or "physiography" by different writers, which has been designated "geomorphic geology" by Powell and the "new geology" or "geomorphology" by the writer; but the term "geomorphy," first employed in a somewhat different connection by Sir William Dawson, though never extensively used with this meaning, is preferable.' (McGee, J. W., Cong. Geol. Internat., p. 199, 1893) 2. 'The description, classification, and correlation of the land forms.' (Hayes, C. W., USGS 19th Ann. Rept., p. 10, 1899) 3. 'Geomorphology, or physiography, is the study of the topographical features of the earth, and of the means by which, and the manner in which, they have been produced.' (Scott, W. B., Textbook, p. 435, 1907) 4. 'Geomorphology may be defined as the branch of science that treats of the surface features of the globe, their form, nature, origin, and development, and the changes they are undergoing. That part of the subject which relates more particularly to the origin, development, and changes of the features is often separately distinguished by the related term geomorphogeny.' (LaForge, Laurence, Geol. Surv. of Ga., Bull. 42, p. 13, 1925) 5. That branch of both physiography and geology which deals with the form of the earth, the general configuration of its surface, and the changes that take place in the evolution of land forms. (BEB2)" (Taken from AGI Glossary.)

"Physiography. 1. '(Greek physis and graphe) A term occasionally used, and especially by American writers, as synonymous with physical geography; a description of existing nature as displayed in the surface arrangement of the globe, its features, atmospheric and oceanic currents, climates, magnetism, life, etc., as well as the changes or variations to which these are subjected.' (Page, David, p. 360, 1865) 2. 'I undertook, therefore, to deliver twelve lectures, not on any particular branch of natural knowledge, but on natural phenomena in general and I borrowed the title "Physiography," which had already been long applied, in a different sense, to a department of mineralogy, for my subject; inasmuch as I wished to draw a clear line of demarkation, both as to matter and method, between it and what is commonly understood by "Physical Geography."' (Huxley, T. H., Physiog., 1878) 3. 'Physiography is an account of physical science as a whole. It describes the substance, form, arrangement, and changes of all the real things of nature in their relations to each other, giving prominence to comprehensive principles rather than isolated facts.' (Mill, H. R., Realm of Nature, p. 3, 1892) 4. 'Physiography has to do primarily with the surface of the lithosphere, and with the relations of air and water to it. Its field is the zone of contact of air and water and land.' (Salisbury, R. D., Physiography, p. 4, 1919) 5. Said by Lobeck to include Climatology, Geomorphology, and Oceanography. (After Lobeck, A. K., Geomorphology, pp. 2-3, 1939)" (Taken from AGI Glossary.)

"Geomorphology. That department of physical geography which deals with the form of the earth, the general configuration of its surface, the distribution of land and water, and the changes that take place in the evolution of land forms." (Webster.)

"Physiography. 1. A description of nature or natural phenomena in general. 2. Physical geography." (Webster.)

U. S. Government Publications

"Geomorphology, that branch of geology dealing with land forms, their genesis and history..." (Leopold, L. B., and Maddock, T., Jr., 1953, The hydraulic geometry of stream channels and some physiographic implications: U.S. Geol. Survey Prof. Paper 252, p. 1.)

SEDIMENTOLOGY

Proposed Definition

Sedimentology.--The study of sedimentary rocks and the processes by which they are formed. (AGI Glossary.)

Discussion

The following is a chronologic account of the proposal and discussion of the term "sedimentology", followed in turn by definitions from other literature sources:

Chronologic Development of Sedimentology

"Sedimentology is here suggested as a term for the subject taught, retaining sedimentation for the act or process of deposition. The new term and its derivatives sedimentologist, sedimentologic and sedimentological, will tend toward clearness. Sedimentology and sedimentation have their analogies in glaciology and glaciation respectively." (Wadell, H., 1932, Sedimentation and sedimentology: Science, v. 75, p. 20.)

"There appeared in Science, January 1, 1932, a short article written by Mr. Hakon Wadell in which it is proposed to designate the range of geologic processes concerned in the formation of the sedimentary rocks as 'sedimentology,' and to term students of sediments, 'sedimentologists.' These terms are not new, as they were discussed some ten years ago by the then chairman of the committee on Sedimentation, Doctor Vaughn, and the writer, and were rejected because they contained roots from two languages. It has not been felt, moreover, that anything would have been gained by the introduction of new terms, and that the range of geologic processes concerned with the formation of sediments is fully covered by the term sedimentation and that the name of sedimentationist is a fitting designation for a student of sediments." (Twenhofel, W. H., 1932, Report of the committee on Sedimentation: Bul. Natl. Research Council, no. 89, p. 18.)

"First in a minor correction of Dr. Twenhofel's statement is needed. In my article 'Sedimentation and Sedimentology,' in Science of January 1, 1932, 'sedimentology' was not proposed as a designation for 'the range of geologic processes concerned in the formation of the sedimentary rocks,' but as a designation for the subject concerned with those processes.

"Since 'terminology' itself is a Latin-Greek formation, there seems to be no reason for disqualifying the term 'sedimentology,' especially since the latter, in the interest of non-ambiguity and logical consistency, is superior to 'sedimentation' as a term for the subject.

"...Generally, the ending -logy signifies a theoretical, scientific, analytical, philosophical study, and the ending -logist usually denotes a student or one versed in the subject.

"Another objection to 'sedimentation' is that it does not readily permit the formation of derivatives corresponding to 'sedimentologic' and 'sedimentological.' These adjectives are useful for such expressions as 'sedimentological (or sedimentologic) research,' 'sedimentological investigations,' 'sedimentological theories,' etc.

"In conclusion, retention of 'sedimentation' for the act or processes of deposition of sediments and adoption of 'sedimentology' as a term for the subject concerned with those processes will tend toward clearness...

"'Sedimentography' is herewith introduced as an additional term signifying the descriptive branch of sedimentology, i.e., that part which deals with the minute phases, megascopic and microscopic features, textures and classification." (Wadell, H., 1933, Sedimentation and sedimentology: Science, v. 77, p. 536-537.)

With reference to usage of "sedimentology" in a report published in the Journal of Sedimentary Petrology:

"Regarding sedimentology: It is difficult to explain the original adoption of this ugly hybrid inappropriate word and its present use in a report in the Journal of Sedimentary Petrology..." (Goldman, M. I., 1950, What is "sedimentology"?: Jour. Sed. Petrology, v. 20, p. 118.)

The above comment was followed by an editorial note requesting further comments concerning this term. The following is the only published reply located:

"'Sedimentation' through the construction of its root and suffix, is a noun of action or act of doing. Geologically it means the act or processes of depositing sediment, and without needlessly changing the prior accepted definitions of the two parts of the word it can mean nothing else. When, through the growth of knowledge, additional terminology is needed and a proper word can be constructed from the accepted parts, there is no justification in giving additional and, therefore, ambiguous meanings to other parts. Such unjustified, incorrect usage occurs when 'sedimentation' is expanded to include all the technology becoming associated with the study of sediments.

"The parts with which such a word can be formed are existing. They are sediment (broadly meaning material deposited) and -ology (which equals -logy, a combining form denoting a science or branch of knowledge). 'Sedimentology,' thus formed, encompasses not only the material itself and its deposition, but also its genesis, transportation and diagenesis; the geochemistry, physics, and statistics applicable to its existence; its economic aspects and control; and so very important, the accurate interpretation of all this knowledge to the sediment may be viewed in its proper perspective within the broad field of natural science." (Lohse, E. A., 1951, Further discussion on "What is 'sedimentology'?": Jour. Sed. Petrology, v. 21, p. 121.)

Other Literature Sources

Text Books

"Petrology has to do with the history of rocks and sedimentary petrology* is concerned with the history of the sedimentary rocks.

"*Miscalled 'sedimentation,' also designated 'sedimentology.'" (Pettijohn, F. J., 1957, Sedimentary rocks: New York, Harper & Bros., 2d ed., p. 1.)

Scientific Journals

"In the broadest sense, sedimentology includes sedimentary processes, description of present-day sediments, methods of study, and interpretation of sedimentary rocks." (Emery, K. O., 1951, Trends in literature of sedimentology: Jour. Sed. Petrology, v. 21, p. 106.)

International Association of Sedimentology

During 1961, the above-named association was formalized. This group publishes a bulletin, the first issue of which appeared in March 1962. The stated objectives of this association are:

"a. To promote the study of sedimentology;
b. To initiate, facilitate and co-ordinate research into, and investigation of those sedimentological problems which require international cooperation; and
c. To provide for discussion, comparison and publication of research results."

The membership requirements are:

"The Association is open to every scientist interested in the study of sedimentation and sedimentary petrology."

These requirements imply a definition of sedimentology similar to the proposed definition.

SEDIMENTATION

Proposed Definition

Sedimentation.--A term applied to the five fundamental processes responsible for the formation of sedimentary rocks: (1) weathering, (2) erosion, (3) transportation, (4) deposition and (5) diagenesis. (Trask, P. D., ed., 1950, Applied sedimentation: New York, John Wiley & Sons, p. 4.)

Text Books

"Sedimentation is thus defined as representing that group of processes that is concerned with the destruction of any kind of rock, the transportation and deposition of the products of destruction together with materials derived from any source whatever, and the cementation or induration of these products so far as such is done by processes that are normal to the surface." (Twenhofel, W. H., 1950, Principles of sedimentation: New York, McGraw-Hill, 2d ed., p. 3.)

"Sedimentation in a strict sense, refers to the processes responsible for the formation of sedimentary rocks, including the origin, transportation, and deposition of rock-forming materials, their diagenesis and lithification. In the broader sense commonly implied, sedimentation expands to encompass sedimentary petrology and sedimentary petrography, which combine to cover the study, description, classification, and interpretation of sedimentary rocks." (Krumbein, W. C., and Sloss, L. L., 1951, Stratigraphy and sedimentation: San Francisco, W. H. Freeman & Co., p. 2.)

"The study of sediments is known as sedimentation or sedimentology. A distinction is made between processes of sedimentation (weathering, transportation, deposition and lithification) and products of sedimentation, the sedimentary rocks." (Krumbein, W. C., and Sloss, L. L., 1951, Stratigraphy and sedimentation: San Francisco, W. H. Freeman & Co., p. 67.)

"...sedimentation, the study of the processes by which sediments are formed, transported, and deposited." (Dunbar, C. O., and Rodgers, J., 1957, Principles of stratigraphy: New York, John Wiley & Sons, p. xi.)

Glossaries and Dictionaries

"Sedimentation. Sedimentation includes that portion of the metamorphic cycle from the separation of the particles from the parent rock, no matter what its origin or constitution, to and including their consolidation into another rock. Sedimentation, thus, includes a consideration of the sources from which the sediments were derived; the methods of transportation from the places of origin to those of deposition; the methods, agents, and environments of deposition; the chemical and other changes taking place in the sediments from the times of their production to their ultimate consolidation; the climatic and other environmental conditions prevailing at the place of origin, over the regions through which transportation takes place, and in the places of deposition; the structures developed in connection with deposition and consolidation; and the horizontal and vertical variations of sediments." (AGI Glossary.)

"Sedimentation. The act or processes of deposition of materials from suspension in the water of streams, lakes, and seas. Sometimes extended to cover deposition by wind and ice." (Rice, C. M., 1940, Dictionary of geological terms: Ann Arbor, Mich., Edwards Bros.)

"Sedimentation. The act or process of depositing sediment." (Webster.)

Scientific Journals

"Sedimentation, as generally understood, is the branch of geology which deals with the processes of sedimentation and origin of the sedimentary rocks." (Wadell, H., 1932, Sedimentation and sedimentology: Science, v. 75, p. 20.)

WEATHERING

Proposed Definition

Weathering.--The group of processes whereby rocks or other materials are altered (physically and [or] chemically) on exposure to the elements of weather.

Text Books

"The term 'weathering of rocks' refers to the changes in degree of consolidation and in composition which take place in the earth's crust within the sphere of influence of atmospheric and hydrospheric agencies.

"Physical weathering is the change of consolidated rock to the unconsolidated state.

"Chemical weathering is the change in chemical composition of consolidated or unconsolidated rock." (Norman, A. G., ed., 1953, Advances in agronomy: New York, Academic Press, p. 221.)

"Weathering may be defined as the disintegration or decomposition of rock in place." (Thornbury, W. D., 1954, Principles of Geomorphology: New York, John Wiley & Sons, p. 36.)

"Physical weathering changes the particle size, surface area, and bulk volume of the parent rock, with no significant change in composition.

"Chemical weathering causes a complete change in physical and chemical properties, accompanied by an increase in bulk volume caused both by the lesser density of new compounds, and by additional porosity of the weathered aggregate.

"Biological weathering is similar to chemical weathering, with changes in both the state of aggregation and in chemical composition." (Krumbein, W. C., and Sloss, L. L., 1956, Stratigraphy and sedimentation: San Francisco, W. H. Freeman and Co., p. 148.)

"Weathering is the response of materials within the lithosphere to conditions at or near its contact with the atmosphere, the hydrosphere, and biosphere." (Keller, W. D., 1957, The principles of chemical weathering: Columbia, Mo., Lucas Brothers, p. 5.)

Glossaries and Dictionaries

"Weathering. The group of processes, such as the chemical action of air and rainwater and of plants and bacteria and the mechanical action of changes in temperature, whereby rocks on exposure to the weather change in character, decay, and finally crumble into soil." (AGI Glossary.)

"Weathering. Action of the elements in altering the color, texture, composition, or form of exposed objects; also alteration so effected." (Webster.)

U. S. Government Publications

"The term 'chemical degradation' applies only to the removal of rock material by corrosion, or chemical erosion, and the subsequent transport of the dissolved products." (Hembree, C. H., and Rainwater, F. H., 1961, Chemical degradation on opposite flanks of the Wind River Range, Wyoming: U.S. Geol. Survey Water-Supply Paper 1535-E, p. 1.)

EROSION

Proposed Definition

Erosion.--The group of processes whereby earthy or rock material is loosened or dissolved and removed from any part of the earth's surface. (After AGI Glossary.)

Text Books

"Erosion is a comprehensive term applied to the various ways by which mobile agencies obtain and remove rock debris. If we wished to be overly technical we might restrict erosion to the acquisition of material by a mobile agent and thereby not consider transportation as a part of it... It is, however, certainly extending the term weathering too far to consider it a part of erosion, although this is often carelessly doen. The two processes are entirely distinct. Weathering can take place without subsequent erosion, and erosion is possible without previous weathering." (Thornbury, W. D., 1954, Principles of geomorphology: New York, John Wiley & Sons, p. 36.)

"The wearing away of the land surface is erosion." (Salisbury, R. P., 1907, Physiography: New York, Henry Holt & Co., p. 129.)

Scientific Journals

"Erosion is the removal of soil particles from their environment." (Committee on Sedimentation, 1962, Am. Soc. Civil Engineers Proc., Hyd. Div., p. 109.)

Glossaries and Dictionaries

"All indurated rocks and most earths are bound together by a force of cohesion which must be overcome before they can be divided and removed. The natural processes by which the division and removal are accomplished make up erosion. They are called disintegration and transportation. (Gilbert, G. K., 1877.)

"A term which includes all processes by which earthy matter or rock is loosened and removed from place to place. In this country it is regarded as including weathering, corrosion, and transportation. (Bryan, K., 1922.)

"The group of processes whereby earthy or rock material is loosened or dissolved and removed from any part of the earth's surface. It includes the processes of weathering, solution, corrosion, and transportation. The mechanical wear and transportation are effected by running water, waves, moving ice, or winds, which use rock fragments to pound or grind other rocks to powder or sand." (Ransome, F. L., 1919.) [Taken from AGI Glossary.]

"Erosion. Act of eroding, or state of being eroded." (Webster.)

SHEET EROSION

Proposed Definition

Sheet Erosion.--Erosion by water in running sheets as distinguished from narrow currents. (AGI Glossary--sheet flood erosion.)

Discussion

In common usage, sheet erosion may include rill erosion.

Text Books

"Slope erosion...the relatively uniform reduction of a fairly smooth ground surface under the eroding force of overland, or sheet, flow which, although by no means uniformly distributed in depth or velocity, is more or less continuously spread over the ground and is not engaged in carving distinct channels into the surface." (Strahler, A. N., 1956, The nature of induced erosion, in Thomas, W. L., Jr., ed., Man's role in changing the face of the earth: Chicago, Univ. of Chicago Press, p. 621.)

Scientific Journals

Sheet erosion. "Removal of a fairly uniform layer of soil or material from the land surface by the action of rainfall and runoff." (Baur, A. J., 1952, Soil and water conservation glossary: Jour. Soil Water Conservation, v. 7.)

"Sheet erosion is erosion by raindrop impact and transportation of eroded material is mainly by sheet or shallow flow over the surface. Since the transporting capacity of such flow is low, only the finer fractions of the soil--silts, clays, and colloids--are moved any considerable distance... The sediment which does get into the channel system constitutes the bulk of the suspended or so-called 'wash load.'" (Gottschalk, L. C., 1957, Problems of predicting sediment yields from watersheds: Am Geophys. Union Trans., v. 38, p. 887.)

U. S. Government Publications

"Rainwash. The water from rain, after it has fallen on the surface of the ground and before it has been concentrated into definite streams; the work done by this water in striking the earth's surface and in transporting debris." (Bryan, K., 1923, Erosion and sedimentation in the Papago County, Arizona, with a sketch of the geology: U.S. Geol. Survey Bull. 730-B, p. 89.)

"Sheet erosion...the more or less uniform removal of the land-surface material by overland flow, including flow in rills and minor shallow gulleys." (Collier, C. R., and others, 1962, Influences of strip mining on the hydrologic environment of parts of Beaver Creek Basin, Kentucky, 1955-59: U.S. Geol. Survey Open File Report, p. 250.)

RILL EROSION

Proposed Definition

Rill Erosion.--Erosion resulting from rivulets of water. (AGI Glossary.)

GULLY EROSION

Proposed Definition

Gully Erosion.--Combined mass wasting and hydraulic action concentrated within relatively narrow spatial limits resulting in steep walled, intermittent stream channels, characterized by steep head cuts.

Text Books

"The very small depressions in which water runs only after smart showers are not always called valleys. If they are small they are called gullies; or if somewhat larger, ravines. Gullies and ravines are but small valleys." (Salisbury, R. D., 1909, Physiography: New York, Henry Holt & Co., 2d ed., p. 118.)

"Gully. Any erosion channel so deep that it cannot be crossed by a wheeled vehicle or eliminated by plowing." (Peterson, H. V., 1950, The problem of gullying in western valleys, in Trask, P. D., Applied sedimentation: New York, John Wiley & Sons, p. 407.)

"Channel erosion. ...consists of the cutting-away of bed and banks of a clearly marked channel which contains the flow at all but the highest flood peaks. Channel erosion takes place in and produces both the gullies and deep shoestring rills incised into previously smooth slopes..." (Strahler, A. N., 1956, The nature of induced erosion, in Thomas, W. L., Jr., ed., Man's role in changing the face of the earth: Chicago, Univ. of Chicago Press, p. 622.)

Scientific Journals

"Channel erosion is popularly considered as being the erosion which occurs after runoff water has left the uplands. Gully erosion would fall in this classification on the basis that a continuous stream channel begins at the base of a gully overfall." (Coldwell, A. E., 1957, Importance of channel erosion as a source of sediment: Am. Geophys. Union Trans., v. 38, p. 908.)

"Arroyos. Verticle-walled, flat-floored channels of ephemeral streams of the semiarid Southwest formed both since 1880 and during some past ages." (Antevs, E., 1952, Arroyos cutting and filling: Jour. Geology, v. 60, p. 375.)

Glossaries and Dictionaries

"Gully Erosion. Removal of soil by running water, with formation of channels that cannot be smoothed out completely by normal cultivation." (AGI Glossary.)

"Gully. A miniature valley or gorge excavated by running water, esp. after rains." (Webster.)

"Arroyo. 1. The channel of an ephemeral or intermittent stream, usually with vertical banks of unconsolidated material 2 feet or more high." (Bryan, K., 1923, U.S. Geol. Survey Bull. 730-B, p. 86.) (Taken from AGI Glossary.)

"Arroyo. A watercourse; also, a small, often dry, gully or channel." (Webster.)

U. S. Government Publications

"Gullied land. ...land on which the soil profile has been destroyed except for small patches between the deep gullies and which is not useful for crops and pasture without extensive reclamation." (U. S. Dept. of Agriculture, 1951, Soil survey manual: Washington, U. S. Govt. Printing Office, p. 295.)

"Gully. A small channel recently cut by running water; smaller than a gulch or ravine." (U.S. Geol. Survey, Topographic Div.)

TRANSPORTATION

Proposed Definition

Transportation.--The movement of sediment particles on the earth's surface by water, ice, air, gravity or biota.

Glossaries and Dictionaries

"Transportation. 'In geology, the shifting of material from one place to another on the earth's surface by moving water, ice, or air. The carriage of mud and dissolved salts by rivers, the passage of a dust-laden whirlwind across a desert, the inland march of sand dunes from a seashore, and the creeping movement of rocks on a glacier are all examples of transportation.' (Ransome, F. L., U.S. Geol. Surv., Prof. Paper 115, p. 186, 1919.)" (AGI Glossary.)

DEPOSITION

Proposed Definition

Deposition.--The laying down of potential rock-forming material. (AGI Glossary.)

Glossaries and Dictionaries

"Deposition. The act of depositing; settling out. In geology, the laying down of sediments; sedimentation." (Rice, Dictionary of Geological Terms.)

"Deposition. That which is deposited; sediment." (Webster.)

DIAGENESIS

Proposed Definition

Diagenesis.--Changes of various kinds occurring in sediments between the time of deposition and the time at which complete lithification takes place. The changes may be due to bacterial action, digestive processes of organisms, to solution and redeposition by permeating water, or to chemical replacement. (AGI Glossary.)

Text Books

Lithification is that complex of processes that converts a newly deposited sediment into an indurated rock.

Diagenesis refers primarily to the reactions which take place within a sediment between one mineral and another or between one or several minerals and the interstitial or supernatant fluids. (Pettijohn, 1957, Sedimentary Rocks, Harper & Brothers, p. 648.)

Glossaries and Dictionaries

"Diagenesis. 1. '...the chemical and physical changes that sediments undergo during and after their accumulation, but before consolidation takes place. It is strange that this subject is so rarely studied since it was as long ago as 1888 that Gümbel directed attention to these changes and coined the word. On the other hand, Walther in 1893 devoted a long chapter to Diagenesis in his Einleitung in der Geologie (pages 693-711), and yet we rarely see the word employed by European or American stratigraphers.' (Schuchert, C., GSA Bull., vol. 31, p. 425, 1920) 2. Changes which take place in rocks as a result of continued accumulation above them, or of the percolation of ground waters through them; e.g., consolidation, cementation, recrystalization, etc. (Holmes, 1928) 3. The alteration of a bed, or a formation consisting of several beds, before consolidation or while in the environment of deposition. Usually occurs before the next bed or formation is definitely deposited over it as a cover. (Grout, F. F., Petrography and Petrology, pp. 336-338, 1932)" (AGI Glossary.)

"Diagenesis. Recombination or rearrangement resulting in a new product, as in the formation of larger crystalline grains from smaller ones." (Rice, Dictionary of Geological Terms.)

"Diagenesis. The reconstructive processes, collectively, operating in sedimentary rocks during or immediately after their deposition to produce changes in them, and caused by the weight of the overlying strata, hot waters, etc." (Webster.)

CHANNEL

Proposed Definition

Channel.--A natural or artificial waterway of perceptible extent which periodically or continuously contains flowing water, or which forms a connecting level between two bodies of water. It has a definite bed and banks which serve to confine the water. (After Committee on Flood Control, 1962, Guide for the development of flood plain regulations: Am. Soc. Civil Engineers Proc., Hyd. Div., p. 106.)

Glossaries and Dictionaries

"Channel. '1. The words bed and channel are frequently employed as synonymous terms when applied to rivers. There is however, a difference, which will be rendered sensible by a little attention. By the word channel I understand generally the course, and more particularly the deepest part of the course, of a stream; that which by the French is termed chenal, and by the Germans thalweg...

"'By this latter term (bed) I understand, as applied to a stream, that part of the channel over which the water generally flows, and that part of the basin of a sea or lake on which the water reposes.' (Jackson, J. R., 1834, Jour. Royal Geog. Soc., v. 4, p. 80-81.)

"2. The deepest portion of a stream, bay, or strait through which the main volume or current of water flows.

"3. The part of a body of water deep enough to be used for navigation through an area otherwise too shallow for navigation." (AGI Glossary.)

"Channel. 1. The bed where a natural stream of water runs. 2. The deeper part of a river, harbor, strait, etc." (Webster.)

U. S. Government Publications

"A 'channel' is a conduit for carrying water in which the flowing stream is in part bounded by an air surface; that is, the stream has a free surface. The word 'channel' is thus used as a synonym for the expression 'open channel.'" (Keulegan, G. H., 1938, Laws of turbulent flow in open channels: Natl. Bur. Standards Jour. Research, v. 21, p. 708.)

"Channel (watercourse). An open conduit either naturally or artifically created which periodically or continuously contains moving water, or which forms a connecting link between two bodies of water. River, creek, run, branch, anabranch, and tributary are some of the terms used to describe natural channels. Natural channels may be single or braided. Canal and floodway are some of the terms used to describe artificial channels." (Langbein, W. B., and Iseri, K. T., 1960, General introduction and hydrologic definitions: U.S. Geol. Survey Water-Supply Paper 1541-A, p. 5.)

STREAMBED

Proposed Definition

Streambed.--The boundary between the unshifting part of a channel at a specific moment and the flowing water or flowing water and sediment. It is the bottom of the bed layer, if a bed layer exists at that point.

Discussion

The apparent stream base may be moving, generally at a velocity which is less than that of the water itself, causing the base to appear stationary.

Glossaries and Dictionaries

"Bed. The floor or bottom on which any body of water rests." (AGI Glossary.)

"Bed. 5. A surface serving as a base; as: a. the bottom of any body of water." (Webster.)

STREAMBED FORMS

Proposed Definition

Streambed Forms.--

Tranquil-Flow Regime.--

Plane Bed Without Movement

Ripples

Dunes

Transition From Dunes To Rapid-Flow Forms

Rapid-Flow Regime.--

Plane Bed With Movement

Standing Sand Waves

Antidunes

Plane Bed.--A streambed without elevations or depressions larger than the maximum size of bed material.

Ripple.--Small ridges and (or) crests, and troughs similar to dunes in shape, but smaller in magnitude, which have rather small width normal to the direction of flow.

Dune.--A sand wave of approximately triangular cross section in a vertical plane in the direction of flow with gentle upstream slope and steep downstream slope. It travels downstream as a result of the movement of the sediment up the upstream slope and the deposition of part of this material on the downstream slope.

Standing Waves.--Symmetrical sand waves and water waves that are in phase and that gradually build up and just as gradually die down. Waves of this type are stationary, or essentially so, and usually develop in series and often reform, somewhat periodically, after disappearing.

Antidunes.--Symmetrical sand and water-surface waves which are in phase, and which move upstream. The surface waves build up with time, becoming gradually steeper on their upstream sides until they break like surf and disappear. These waves usually develop, break, and reform in groups of two or more.

(Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. VII.)

Early Sources

"When the conditions are such that the bed load is small, the bed is molded into hills, called dunes, which travel downstream. Their mode of advance is like that of eolian dunes, the current eroding their upstream faces and depositing the eroded material on the downstream faces. With any progressive change of conditions tending to increase the load, the dunes eventually disappear and the debris surface becomes smooth. The smooth phase is in turn succeeded by a second rhymthmic phase, in which a system of hills travel upstream. These are called antidunes, and their movement is accomplished by erosion on the downstream face and deposition on the upstream face. Both rhythms of debris movement are initiated by rhythms of water movement." (Gilbert, G. K., 1914, The transportation of debris by running water: U.S. Geol. Survey Prof. Paper 86, p. 11.)

Scientific Journals

"A sand-wave is a ridge on the bed of a stream formed by the movement of the bed material which is usually approximately normal to the direction of flow, and has a shape somewhat resembling a water wave.

"A dune is a sand wave of approximately triangular cross section (in a vertical plane in the direction of flow) with gentle upstream slope and steep downstream slope, which travels downstream by the movement of the sediment up the upstream slope, and the deposition of it on the downstream slope.

"An anti-dune is a sand wave, indicated on the water surface by a regular undulating wave, in appearance like that formed behind a stern wheel steamboat. These ridges move, usually upstream. The surface waves become gradually steeper on their upstream sides until they break like surf and disappear. These waves are usually in series and often reform after disappearing." (Lane, E. W., Chm., 1947, Report of the subcommittee on sediment terminology: Am. Geophys. Union Trans., v. 28, p. 938.)

"The most common concept of the mechanics of bed-load movement is that of a dragging force existing on the stream bed due to the flowing water. This force, termed the 'tractive force,' is the entraining force exerted at the base of a prism of water of unit area of the bed and of height equal to the water depth, sliding (under the influence of gravity) down an inclined plane having a specified slope. When the tractive force is sufficient to overcome the resistance of the particles, sediment begins to move as bed load. The force which creates the commencement of movement of the bed material is called the critical tractive force." (Chien, N., 1954, The present status of research on sediment transport: Am. Soc. Civil Engineers Proc., v. 120, p. 848.)

U. S. Government Publications

"Antidune. A transient form of ripple on the stream bed analogous to a sand dune; an antidune progressively moves upstream." (Leopold, L. B., and Maddock, T., Jr. 1953, The hydraulic geometry of stream channels and some physiographic implications: U.S. Geol. Survey Prof. Paper 252, p. iv.)

"Point bar. A point bar is a deposit formed on the inside, or convex side, of a river bend by lateral accretion. Deposition is related to the existence of circulatory motion or helicoidal flow associated with the channel bend. Deposition on the convex bank and the concomitant erosion of the concave bank both tend to be the greatest just downstream from the position of maximum curvature... Together the processes of erosion and deposition tend to maintain a constant channel width during lateral shifts of the channel." (Wolman, M. G., and Leopold, L. B., 1957, River flood plains: some observations on their formation: U.S. Geol. Survey Prof. Paper 282-C, p. 91.)

"Regime of flow-sand bed channel.

"Plane bed.....	For flow prior to movement.
"Ripples.....	Small, uniform sand waves, with little sediment movement.
"Dunes.....	Much larger more irregular sand waves, with a great deal of turbulence.
"Standing waves.....	Both the water surface and the bed are characterized by standing waves, often termed 'sand waves.'
"Antidunes.....	The 'sand waves' move upstream until at some critical point they break, then reform."

(Dawdy, D. K., 1961, Depth-discharge relations of alluvial streams--discontinuous rating curves: U.S. Geol. Survey Water-Supply Paper 1498-C, p. 1.)

SEDIMENT

Proposed Definition

Sediment.--Solid material, both mineral and organic, that is in suspension, is being transported or has been moved from its site of origin by air, water, gravity or ice and has come to rest on the earth's surface either above or below sea level. (After AGI Glossary Supplement.)

Discussion

The proposed definition of sediment is intended to be an all inclusive term. Proposed definitions for sediments which can be definitely categorized with regard to transporting and depositing media follow.

Text Books

"Sediments are aggregates of particles that come to rest in some place after having been transported laterally or vertically for some distance." (Trask, P. D., ed., 1950, Applied sedimentation: New York, John Wiley & Sons, p. 3.)

"Sediments are the materials with which sedimentation is concerned. They are the materials derived from any source whatever: rocks, organic matter, volcanic materials, and particles from outer space; transported in any way and in any medium from the places of origin on the earth, or where they appear on the earth, to the places of deposition, to be deposited under conditions of pressure and temperature that approximate those normal to the surface." (Twenhofel, W. H., 1950, Principles of sedimentation: New York, McGraw-Hill, 2d ed., p. 3.)

"A sediment is a deposit of solid material on the earth's surface from any medium (air, water, ice) under normal conditions of the surface." (Krumbein, W. C., and Sloss, L. L., 1951, Stratigraphy and sedimentation: San Francisco, W. H. Freeman & Co., p. 67.)

Glossaries and Dictionaries

"Sediment. 1. 'Anything settling down from suspension in water. Sedimentary rocks are rocks made up of sediment, loosely applied to all stratified rocks.' (Oldham, R. D., Geol. Gloss., p. 48, London, 1879) 2. 'In the singular the word is usually applied to material in suspension in water or recently deposited from the waters of streams, lakes, or seas, and in a more general sense to deposits of wind and ice. Such deposits that have been consolidated are generally referred to as sedimentary rocks.' (Bryan, K., USGS Bull. 730-B, 1922)" (Taken from the AGI Glossary.)

"Sediment. 1. Solid material settled from suspension in a liquid. 2. Solid material, both mineral and organic, that is in suspension, is being transported or has been moved from its site of origin by air, water or ice and has come to rest on the earth's surface either above or below sea level." (Taken from the AGI Glossary Supplement)

"Sediment. In the singular the word is usually applied to material in suspension in water or recently deposited from suspension. In the plural, the word is applied to all kinds of deposits from the waters of streams, lakes, or seas, and in a more general sense to deposits of wind and ice. Such deposits that have been consolidated are generally referred to as sedimentary rocks." (Rice, C. M., 1940, Dictionary of geological terms: Ann Arbor, Michigan, Edwards Brothers.)

"Sediment. 1. The matter which settles to the bottom from a liquid; lees; dregs. 2. Geol.--Material, or a mass of it, deposited, as by water." (Webster.)

Scientific Journals

"...the author would recommend the term sediment for the general classification of non-floating material moved by a fluid..." (Lane, E. W., 1941, Need for standardization of terms used in studies of the transportation and deposition of sediment, in Howe, J. W., ed., Investigations of the Iowa Institute of Hydraulic Research 1939-1940: Univ. of Iowa, Studies in Eng., Bull. 26, p. 13.)

U. S. Government Publications

"...the term 'sediment' is used to denote the composite loads of fragmental material transported by, suspended in, or deposited by a flowing stream, without regard to the size of the individual particle or groups of particles." (Inter-Agency Report No. 8, 1948, Measurement of the sediment discharge of streams: Washington, U. S. Govt. Printing Office, p. 16.)

"Sediment is fragmental material transported by, suspended in, or deposited by, water or air, or accumulated in beds by other natural means." (Love, S. K., and Benedict, P. C., 1948, Discharge and sediment loads in the Boise River drainage basin, Idaho: U.S. Geol. Survey Water-Supply Paper 1048, p. 20.)

"Sediment is fragmental material that originates mostly from rocks and is transported by, suspended in, or deposited from water or air, or is accumulated in beds by other natural agencies." (Colby, B. R., Hembree, C. H., and Rainwater, F. H., 1956, Sedimentation and chemical quality of surface waters in the Wind River Basin, Wyo.: U.S. Geol. Survey Water-Supply Paper 1373, p. 37.)

"Sediment. Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited by water or air or is accumulated in beds by other natural agencies." (Langbein, W. B., and Iseri, K. T., 1960, General introduction and hydrologic definitions: U.S. Geol. Survey Water-Supply Paper 1541-A, p. 17.)

"Sediment. Fragmental material that originates from weathering of rocks and is transported by, suspended in, or deposited by water." (Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. vii.)

SUSPENDED SEDIMENT

Proposed Definition

Suspended Sediment.--Sediment in suspension in air or water. It is maintained in suspension by the upward components of turbulent currents or by colloidal suspension.

Discussion

Definitions of this term found in the literature often specify "flowing water." However, suspended sediment may also be present in a fluid which is not flowing.

Text Books

"Suspended sediment: Particles which do not settle readily to the bottom in a fluid." (Dunbar, C. O., and Rodgers, J., 1957, Principles of stratigraphy: New York, John Wiley & Sons, p. 14.)

U. S. Government Publications

"Suspended sediment--Sediment which remains in suspension in flowing water for a considerable period of time without contact with the stream bed." (Inter-Agency Report no. 8, 1948, Measurement of the sediment discharge of streams: Washington, U. S. Govt. Printing Office, p. 17.)

"Suspended sediment is sediment that remains in suspension in water for a considerable period of time without contact with the bottom." (Love, S. K., and Benedict, P. C., 1948, Discharge and sediment loads in the Boise River drainage basin, Idaho: U.S. Geol. Survey Water-Supply Paper 1048, p. 20.)

"Suspended sediment or suspended load is sediment that is moved in suspension in water and is maintained in suspension by the upward components of turbulent currents or by colloidal suspension." (Colby, B. R., and Hembree, C. H., 1955, Computations of total sediment discharge Niobrara River near Cody, Nebraska: U.S. Geol. Survey Water-Supply Paper 1357, p. 5.) (Also in Water-Supply Paper 1373 and Water-Supply Paper 1476.)

FLUVIAL SEDIMENT

Proposed Definition

Fluvial Sediment.--Sediment transported or deposited by surface streams.

Discussion

Outwash and ice contact deposits may be considered a special type of fluvial sediment. Alluvium is essentially synonymous.

Glossaries and Dictionaries

"Outwash. 1. ...stratified drift that is stream built --'washed out'--beyond the glacier itself. 2. Stratified drift deposited by meltwater streams beyond active glacier ice." (Taken from AGI Glossary.)

U. S. Government Publications

"Fluvial sediment is sediment that is transported by, suspended in, or deposited from water." (Colby, B. R., Hembree, C. H., and Rainwater, F. H., 1956, Sedimentation and chemical quality of surface waters in the Wind River Basin, Wyoming: U.S. Geol. Survey Water-Supply Paper 1373, p. 37.)

LACUSTRINE SEDIMENT

Proposed Definition

Lacustrine Sediment.--Sediment in a lake or a deposit in a lake.

Glossaries and Dictionaries

"Lacustrine deposit. Material deposited in a lake environment; debris is largely a product of fluviatile action, although in some cases much glacial debris may have been carried into the lake; usually fairly uniform in texture but variable in chemical composition; organic constituents are of fresh water or terrestrial origin and differ from those found in estuarine deposits." (AGI Glossary.)

EOLIAN SEDIMENT

Proposed Definition

Eolian Sediment.--Sediment transported or deposited by wind.

Glossaries and Dictionaries

"Eolianite...all consolidated sedimentary rocks which have been deposited by wind." (AGI Glossary.)

TILL

Proposed Definition

Till.--Sediment transported or deposited by a glacier, resulting in an unsorted, unstratified deposit.

Text Books

"Till is an unstratified and unsorted aggregate resulting from ice deposition. Tillite is the lithified equivalent." (Twenhofel, W. H., 1950, Principles of sedimentation: New York, McGraw-Hill, 2d ed., p. 301.)

"The term till is properly applied only to unstratified and unsorted ice-laid materials." (Pettijohn, F. J., 1957, Sedimentary rocks: New York, Harper & Bros., 2d ed., p. 266.)

"The name 'drift' has come down from the days when what we now know to be glacial deposits were thought to represent material rafted by icebergs during the Noachian deluge. The word survives even though it has lost its original connotation. In fact, it is sometimes a convenient term to have at hand, particularly if we want to be noncommittal and merely indicate that materials of glacial origin are present in an area without saying whether they were deposited by ice or water. We should, however, restrict the term 'till' to those deposits laid down by ice." (Thornbury, W. D., 1957, Principles of geomorphology: New York, John Wiley & Sons, p. 386.)

Glossaries and Dictionaries

"Till. 1. ...a stiff clay full of stones varying in size up to boulders... To this deposit the name of boulder clay or till has been given... (It is the product of) abrasion carried on by the ice sheet as it moved over the land. 2. The term 'till' was first applied in Scotland to the stiff, unstratified clays containing angular, subangular and rounded blocks of rock, mostly polished and striated, and is now generally used as synonymous with 'boulder clay.'" (AGI Glossary.)

"Till. Unstratified glacial drift, consisting of clay, land, gravel and boulders intermingled." (Webster.)

COLLUVIAL SEDIMENT

Proposed Definition

Colluvial Sediment.--Sediment transported or deposited by mass movements.

Discussion

Mass movement includes: creep, mudflow, earth-flow, avalanches and landslides.

Text Books

"Colluvial deposits...debris carried by slope wash into the valley and mixed with varying amounts of talus." (Thornbury, W. O., 1957, Principles of geomorphology: New York, John Wiley & Sons, p. 172.)

Glossaries and Dictionaries

"Deposits, colluvial. Deposits composed chiefly of the debris from sheet erosion deposited by unconcentrated surface runoff or slope wash, together with talus and other mass-movement accumulations." (AGI Glossary.)

BED SEDIMENT

Proposed Definition

Bed Sediment.--The sediment which forms the bed of a stream.

Discussion

"Bed Sediment," as defined here, does not include a particle size connotation. The term is proposed as a replacement for "bed material." The latter term has been used to refer to coarse material and to refer to material which forms the streambed. (See "Coarse Sediment Load.")

Scientific Journals

"Bed-material composition is determined from samples taken in the bottom of the channel in the reach under consideration immediately after a flood has receded to the normal low-water stage." (Einstein, H. A., Anderson, A. C., and Johnson, J. W., 1940, A distinction between bed-load and suspended load in natural streams: Am. Geophys. Union Trans., pt. II, 21st Ann. Mtng., p. 632.)

U. S. Goverment Publications

"Bed material is the material of which the bed is composed, and may be the result of either suspended or bed-load movement, or both, or, in some cases, may even be residual." (Inter-Agency Report no. 2, 1940, Equipment used for sampling bed-load and bed-load material: Washington, U. S. Govt. Printing Office, p. 10.)

"Bed material: The sediment mixture of which the moving bed is composed." (Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U. S. Dept. Agr. Soil Conserv. Service Tech. Bull. no. 1026, p. 4.)

"Bed material is a size classification and includes the sizes of sediment particles that are found in appreciable quantity near the surface of the streambed, but the bed material may be transported anywhere between the bed and the water surface." (Colby, B. R., 1961, Effect of depth of flow on discharge of bed material: U.S. Geol. Survey Water-Supply Paper 1498-D, p. 2.)

"Bed material: The material of which a stream bed is composed." (Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. viii.)

CONCENTRATION

SEDIMENT CONCENTRATION

Proposed Definition

Sediment Concentration.--The quantity of sediment relative to the quantity of transporting fluid, or fluid sediment mixture.

(In the U.S. Geological Survey, "sediment concentration" is often abbreviated to "concentration." It is expressed in parts per million [ppm], i.e., the weight of dry solids divided by the weight of the water-sediment mixture.)

Scientific Journals

"The sediment discharge concentration...is thus the total rate of sediment transportation (including bed load) divided by the discharge and is not necessarily the same as the average concentration of sediment in suspension in the open channel." (Brooks, N. H., 1958, Mechanics of streams with movable beds of fine sand: Am. Soc. Civil Engineers Trans., v. 123, p. 530.)

U. S. Government Publications

"Sediment concentration. The weight of solids in a water-sediment mixture expressed either as the weight of dry solids per unit volume of the sample or as the ratio of the weight of dry solids to the weight of the sample." (Inter-Agency Report no. 8, 1948, Measurement of the sediment discharge of streams: Washington, U. S. Govt Printing Office, p. 17.)

"The concentration is defined as the weight of solids per unit volume of water-sediment mixture." (Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U. S. Dept. Agr. Soil Conserv. Serv. Tech. Bull. no. 1026, p. 39.)

"Sediment concentration is the ratio of the weight of sediment to the weight of water-sediment mixture, in parts per million. A part per million is a unit weight of sediment in a million unit weights of water-sediment mixture." (Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 9.)

"Total sediment concentration is the concentration of all the sediment passing a given section in a stream." (Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 10.)

"Equipment currently available for sampling suspended sediment does not collect water-sediment mixture throughout the entire depth of flow; consequently, the concentration and particle size distribution in only part of the flow can be determined from suspended-sediment samples. The unsampled flow near the stream bed, or flow in the unsampled zone, normally contains higher concentrations and coarser particle-size distributions than the sampled flow, or flow in the sampled zone. Thus, the concentration of suspended-sediment samples is usually lower than the suspended-sediment concentration for the entire depth, and the particle sizes of the samples are usually smaller than the particle sizes for the entire depth." (Colby, B. R., and Hubbell, D. W., 1961, Simplified methods for computing total sediment discharge with the modified Einstein procedure: U.S. Geol. Survey Water-Supply Paper 1593, p. 1.)

"Sediment concentration. The ratio of dry weight of sediment to total weight of the water-sediment mixture, usually expressed in parts per million (ppm)." (Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. vii.)

SPATIAL CONCENTRATION

Proposed Definition

Spatial Concentration.--A mean value of concentration for a selected depth (point) in a stream vertical or stream cross section at any given time or for any given period of time.

VELOCITY WEIGHTED CONCENTRATION

Proposed Definition

Velocity Weighted Concentration.--A mean value of concentration weighted by the velocity (discharge) in a stream vertical or in a stream cross section; the concentration of sediment in samples collected with a depth-integrating sampler.

OBSERVED SUSPENDED SEDIMENT CONCENTRATION

Proposed Definition

Observed Suspended Sediment Concentration.--Concentration of sediment in a stream vertical or stream cross section determined from samples representative of the water-sediment mixture and distribution of flow.

Discussion

"Observed concentrations" are obtained from samples collected with depth- or point-integrating samplers. "Depth-integrated samples" are weighted with respect to the vertical velocity distribution during the collection process. Point-integrated samples are weighted with respect to velocity at each sampling point. Velocities for the latter method of collection are obtained with a current meter or from nozzle intake characteristics and sampling time.

Observed concentrations may be either "velocity weighted" or "spatial" depending on manner of collection and data treatment.

This term and definition are proposed because:

a. The term itself has meaning. "Measured suspended sediment concentration" probably is more precise in the view of individuals acquainted with the significance of "measured." However, in this instance "observed" should be understood to include "measured."

b. It is consistent with Langbein, U.S. Geol. Survey Water-Supply Paper 1541-A. (1960)

c. It conforms with the usage in U.S. Geol Survey Prof. Paper 412, Fig. 12. (Langbein, 1961, p. 14.)

Scientific Journals

"The recommended method for determining the concentration of suspended sediment is, weight of dried sediment divided by weight of sample, including weight of solids, water, and dissolved material. Since for sediment concentrations less than one percent the results computed by the following two methods differ less than one percent from the results obtained by the recommended method, for such concentrations the use of the following methods is permissible:

"(1) Weight of the dried sediment divided by weight of distilled water with a volume equal to that of the sample, or

"(2) Weight of the dried sediment divided by weight of the water in the sample, including the dissolved material.

"The ratio used in expressing the concentration of suspended sediment should be given in either parts per million (ppm) or percent." (Lane, E. W., Chm., 1947, Report of the Subcommittee on Sediment Terminology: Am Geophys. Union Trans., v. 28, p. 937.)

"The concentration determined from a depth-integrated sample is assumed to represent the velocity-weighted concentration of suspended sediment from the surface to the stream bed. Because the concentration in the unsampled zone exceeds the velocity-weighted concentration in the sampled depth, the computed suspended-sediment load is less than the actual suspended-sediment load.

"Therefore, the unmeasured discharge of suspended sediment is represented by the excess concentration of suspended sediment at each point in the unsampled depth multiplied by the velocity at each point. Also, sediment particles transported in more or less continuous contact with the bed are part of the unmeasured sediment discharge." (Schroeder, K. B., and Hembree, C. H., 1956, Application of the modified Einstein procedure for computation of total sediment load: Am. Geophys. Union Trans., v. 37, p. 197.)

U. S. Government Publications

"True mean sediment concentration in a vertical is a quantity such that when multiplied by the mean velocity in the vertical, the value of the actual suspended sediment discharge in a unit width of the stream is obtained." (Inter-Agency Report no. 3, 1941, Analytical study of methods of sampling suspended sediment: Washington, U. S. Govt. Printing Office, p. 21.)

"Mean concentration is a composite of the concentrations at different points of flow and is obtained by weighting the concentration at each point with the stream velocity at that point. Therefore, the concentration of a depth-integrated sample or samples is a mean concentration.

"Measured suspended-sediment concentration is the mean concentration of the measured suspended sediment." (Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 9.)

LOAD

SEDIMENT LOAD

Proposed Definition

Sediment Load.--The sediment being moved by a stream at a cross section.

Early Sources

"Load. The quantity of debris transported by a stream through any cross section in a unit of time is its load at that section. A part is carried in suspension and a part by traction, but as we are here concerned with traction only, the tractional load is to be understood when the word is used with specification. Load is measured in grams per second, gm/sec. For certain engineering purposes it is desirable to consider load as volume, not as the sum of the volumes of individual grains, but as the gross space occupied by the debris as a natural deposit. For the debris used in the experiments in stream traction, with the mixture of sizes ordinarily found in a river deposit, the weight of 1 cubic foot is about 50,000 grams, or 110 pounds. The symbol for load is 'L.'" (Gilbert, G. K., 1914, The transportation of debris by running water: U.S. Geol. Survey Prof. Paper 86, p. 35.)

Text Books

"Load. The quantity of material actually transported by a current. This is usually somewhat less than the actual capacity of the current." (Twenhofel, W. H., 1939, Principles of sedimentation: New York, McGraw-Hill, p. 194.)

Glossaries and Dictionaries

"Load. 1. In erosion and corrasion the material which is transported may be called the 'load.' The load is transported by two methods, a portion floats with the water, and another portion is driven along the bottom." (AGI Glossary.)

Scientific Journals

"The word 'load' should be used only in referring to a material in motion and the word 'discharge' should be used in referring to the amount of material moved in terms of volume or weight per unit time.

"The total load could thus be divided into parts in four different ways as follows: (1) rolling-sliding or contact load, saltation load, and suspended load; (2) traction load and suspended load; (3) bed load and non-bed load; (4) bed-material load and wash load." (Lane, E. W., 1941, Need for standardization of terms used in studies of the transportation and deposition of sediment, in Howe, J. W., ed., Investigations of the Iowa Institute of Hydraulic Research 1939-1940: Univ. of Iowa, Studies in Eng., Bull. 26, p. 13.)

"Sediment may be transported by flowing water in two essentially different ways--by rolling or sliding along the bed of the stream channel or in suspension in the body of the fluid. The material transported is called respectively, the 'bed load of the stream,' or simply 'bed load' and the 'suspended load.' Just above the bed a continual interchange of material is occurring between the bed and the overlying fluid and in this locality it is obviously difficult to distinguish between the bed load and the suspended load. The two types of transportation are by no means independent. They are separated only for convenience in studying them and referring to them." (Vanoni, V. A., 1946, Transportation of suspended sediment by water: Am. Soc. Civil Engineers Trans., v. III, p. 63.)

"So far sediment motion has been described separately as suspended-load and bed-load, because of the difference in laws which govern its motion. This does not imply that the two modes of transportation are completely unrelated. Indeed sediment motion must be continuous from the bed up to the water surface. Not only the bed-load, but the suspension as well, must relate to the composition of the stream bed." (Chein, H., 1954, The present status of research on sediment transport: Am. Soc. Civil Engineers Proc., v. 120, p. 581)

"A load as generally understood is a normal gravity stress, and the word will be used here in this sense. The same word is, however, still sometimes applied to the time rate at which the load of transported grains is carried along a stream. This quite different quantity will here be called the 'transport rate.'" (Bagnold, R. A., 1956, The flow of cohesionless grains in fluids: Royal Soc. [London] Philos. Trans., v. 249, p. 249.)

"Most investigations of sediment movement have been largely devoted to the three so-called modes of transport: contact, saltation, and suspended. These modes of transport usually have been studied individually rather than as indivisible parts of the total sediment movement. Because in reality there is no sharp dividing line between the three modes of transport, the individual approach has not been too successful for determining the total load of streams flowing in channels that are easily eroded or channels that are stable except during high flows." (Benedict, P. C., 1957, Fluvial sediment transportation: Am. Geophys. Union Trans., v. 38, p. 897.)

U. S. Government Publications

"...Note that a distinction is being made between sediment load (the material itself) and sediment discharge (the rate of transportation of the sediment load)." (Vanoni, V. A., and Brooks, N. H., 1957, Laboratory studies of the roughness and suspended load of alluvial streams: Final Report to Corps of Engineers, U. S. Army, Mo. River Div., Contract VA-25-075-eng-3866, p. 28.)

"Total load. The amount of sediment that is transported by water in a given length of time." (Simons, D. C., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. viii.)

SUSPENDED LOAD

Proposed Definition

Suspended Load.--The sediment in suspension which is transported at essentially the velocity of the water.

Discussion

"Non-bed" load was proposed by Lane (see below) to refer to material not being transported on the bed of a stream. This term is objectional because of the negative approach.

Based on the definitions of "load" and "suspended sediment," "suspended load" should incorporate the following points:

1. The sediment is in suspension.
2. The sediment is in the process of being transported.

Early Sources

Suspended load. "In the process by which running water transports detritus two factors are distinguished...The smaller particles are lifted far from the bottom, are sustained for long periods, and are distributed through the whole body of the current; they constitute the suspended load." (Gilbert, G. K., 1906, GSA Bull., v. 18, as taken from AGI Glossary.)

Scientific Journals

"In order to open up a discussion which it is hoped will lead to a more explicit meaning of the term 'bedload,' the author would like to have consideration given to the following general definitions: Bed load is the coarse sediment which is being moved on or near the bed. Bed load would therefore include the sliding, rolling, and saltation load plus the coarser portions of the suspended load, if any is present. It is believed that this definition is in substantial agreement with the more extensive use of the term. Since this proposed definition of 'bed load' includes in it part of the suspended load, the remainder of the load cannot be called 'suspended load,' and it is recommended that the term 'non-bed load' be used." (Lane, E. W., 1941, Need for standardization of terms used in studies of the transportation and deposition of sediment, in Howe, J. W., ed., Investigations of the Iowa Institute of Hydraulic Research 1939-1940: Univ. of Iowa, Studies in Eng., Bull. 26, p. 13.)

"Suspended load can be used for either (1) the material moving in suspension in a fluid, being kept up by the upward components of the turbulent currents or by colloidal suspension, or (2) the material collected in or computed from samples collected with a suspended load sampler. (A suspended load sampler is a sampler which attempts to secure a sample of the water with its sediment load without separating the sediment from the water.) Where it is necessary to distinguish between the two meanings given above, the first one may be called the 'true suspended load.'" (Lane, E. W., Chm., 1947, Report of the subcommittee on sediment terminology: Am Geophys. Union Trans., v. 28, p. 936.)

"The suspended load is defined as that part of the load whose like weight component is in equilibrium with a normal fluid stress originating in impulses by turbulent eddies. This stress is supposed transmitted not to the bed grains but between them as an excess static fluid pressure." (Bagnold, R. A., 1956, The flow of cohesionless grains in fluids: Royal Soc. [London] Philos. Trans., v. 249, p. 250.)

U. S. Government Publications

"Suspended load. Suspended load is defined as sediment which remains in suspension for a considerable period of time without contact with the bottom. It may also be defined as sediment which is being transported by a stream out of contact with the bed and banks of the stream, being bounced or lifted into the stream by the action of forces other than the vertical components of flow and being carried forward by the horizontal components before settling back to the bottom." (Inter-Agency Report no. 3, 1941, Analytical study of methods of sampling suspended sediment: Washington, U. S. Govt Printing Office, p. 14.)

"Suspended load. Particles moving outside the bed layer. The weight of suspended particles is continuously supported by the fluid." (Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U. S. Dept. Agr. Soil Conserv. Serv. Tech. Bull. 1026, p. 4.)

"...suspended load, ...particles move entirely surrounded by and at essentially the velocity of the water." (Laursen, E. M., 1957, An investigation of the total sediment load: Final report to the Office of Naval Research, contract N8onr-500(02), p. 1.)

"Sediment transported by a stream may conveniently be divided into suspended load and bed load, but it must be understood that, depending on the flow conditions, sediment may at one time be part of the suspended load and at another time part of the bed load." (Leopold, L. B., and Maddock, T., Jr., 1953, The hydraulic geometry of stream channels and some physiographic implications: U.S. Geol. Survey Prof. Paper 252, p. 19.)

"Suspended sediment or suspended load is sediment that is moved in suspension in water and is maintained in suspension by the upward components of turbulent currents or by colloidal suspension." (Colby, B. R., and Hembree, C. H., 1955, Computations of total sediment discharge Niobrara River near Cody, Nebraska, U.S. Geol. Survey Water-Supply Papers 1357 [p. 5], 1373 [p. 37] and 1476 [p. 8].)

"Note that a distinction is being made between sediment load (the material itself) and sediment discharge (the rate of transportation of the sediment load." (p. 28)

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"The suspended load of a natural stream includes both bed-material load and wash load." (p. 68) (Vanoni, V. A., and Brooks, N. H., 1957, Laboratory studies of the roughness and suspended load of alluvial streams: Final report to the Corps of Engineers, U. S. Army, Mo. River Div., contract VA-25-075-eng-3866.)

"Suspended load. The sediment moving in suspension in a fluid as a result of turbulent currents and (or) by colloidal suspension." (Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. viii.)

COARSE SEDIMENT LOAD

Proposed Definition

Coarse Sediment Load.--Coarse sediment load, as related to transport processes, is that part of the suspended sediment load of a stream which is composed of particle sizes found in appreciable quantities in the shifting portions of the streambed.

Discussion

The term Coarse Sediment Load is introduced here to eliminate overlapping of terms and resultant confusion. In previous usage it is synonymous with bed-material load. The quantity and size distribution varies with the hydraulic properties of the flow, streambed forms, and size distribution of the sediment in the streambed.

Text Books

"...that part (of a sediment load) which is governed mostly by its ability to be moved in the stream channel is termed bed-material load." (Trask, P. D., 1950, Applied sedimentation: New York, John Wiley & Sons, p. 63.)

Scientific Journals

"Bed-material load is part of the suspended sediment load of a stream which is composed of particle sizes found in appreciable quantities in the shifting portions of the streambed." (Lane, E. W., Chm, 1947, Report of the sub-committee on sediment terminology: Am. Geophys. Union Trans., v. 28, p. 937.)

"Bed material load consists of those grain sizes which are found in significant quantities in the river bed, including sands, gravels, and, in some cases, certain silt fractions... The rate of transport of bed-material load is a function of the hydraulic properties of the flow and bed composition; hence a change in the movement of bed-material load through a reach while the discharge remains constant can effect significant changes in the bed elevation and the bed composition... During high stages, bed-material transport is confined mainly to the sandy river channel, while wash load is transported throughout the entire valley cross section." (Harrison, A. S., 1952, Deposition at the heads of reservoirs: Hydraulics Conf., 5th, State Univ. of Iowa, Proc., p. 201.)

"The bed material load refers to the part of the moving particles which are abundantly available in the bed. The rate of this load is governed primarily by its ability to be moved in the stream channel and bears a definite relationship to the flow. The bed material load is always transported to its capacity, and its rate is the controlling factor in determining the stability of the stream channel." (Einstein, H. A., and Chien, N., 1955, Effects of heavy sediment concentration near the bed on the velocity and sediment distribution: Univ. of Calif., Institute of Research, MRD Sed. Series 33, p. 31.)

U. S. Government Publications

"Bed-material load. That part of the sediment load which consists of grain sizes represented in the bed." (Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U. S. Dept. of Agr. Soil Conserv. Serv. Tech. Bull. 1026, p. 4.)

FINE SEDIMENT LOAD

Proposed Definition

Fine Sediment Load.--Fine sediment load, as related to transport processes, is that part of the suspended load of a stream which is composed of particle sizes not generally found in shifting portions of the streambed.

Discussion

This term is intended as a replacement for "wash load." "Fine Sediment load" implies its definition, whereas "wash load" does not.

Suspended load includes the fine sediment load, however, it does not necessarily equal it because coarse sediment load is present as part of the suspended load.

Text Books

"...so called wash load of streams (i. e., suspended material which is almost uniformly distributed from surface to bed but is not present in any appreciable amount in the bed itself)." (Rouse, H., 1950, Engineering Hydraulics: New York, John Wiley & Sons, p. 776.)

"Wash load. ...that part of the load the rate of which is governed by its availability in the watershed is termed wash load. ...wash-load particles are not deposited in the stream channels on their way from the place of erosion down to a point of measurement. They travel with the same velocity as the flow." (Trask, P. D., ed., 1950, Applied sedimentation: New York, John Wiley & Sons, p. 63.)

Scientific Journals

"Wash load is that part of the total sediment-load composed of all particles finer than the limiting size (42-mesh sieve for the Enoree River) which usually is washed into and through the reach under consideration.

"Wash load may enter a river by sheet-wash, bank-caving, and other causes." Einstein, H. A., Anderson, A. G., and Johnson, J. W., 1940, A distinction between bed-load and suspended load in natural streams: Am. Geophys. Union Trans., pt. II, 21st Ann. Mtng., p. 632.)

"'Wash load' is that composed of sizes not readily available in the bed." (Lane, E. W., 1941, Need for standardization of terms used in studies of the transportation and deposition of sediment, in Howe, J. W., ed., Investigations of the Iowa Institute of Hydraulic Research 1939-1940: Univ. of Iowa, studies in Eng., Bull. 26, p. 13.)

"Wash load is that part of the sediment load of a stream which is composed of particle sizes smaller than those found in appreciable quantities in the shifting portions of the stream bed." (Lane, E. W., 1947, Report of the subcommittee on sediment terminology: Am. Geophys. Union Trans., v. 28, p. 937.)

"Wash load is silt and clay, not generally found in significant quantities in a river bed. It often comprises the major portion of the total sediment load. ...the movement of wash load through a reach will not alter the bed significantly...the rate of wash load transported seems to be governed mainly by its supply." (Harrison, A. S., 1952, Deposition of the heads of reservoirs: Hydraulics Conf., 5th, State Univ. of Iowa, Proc., p. 201.)

U. S. Government Publications

"Wash load. That part of the sediment load which consists of grain sizes finer than those of the bed." (Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U. S. Dept. Agr. Soil Conserv. Serv. Tech. Bull. 1026, p. 4.)

"The wash load refers to the part of the moving particles which is washed through the stream channel without any deposition. It is not found in any significant amount in the bed. The rate at which the 'wash load' is moving through a reach depends only on the rate with which these particles become available in the watershed and not on the ability of the flow to transport them. It is this part of the material, nevertheless, which may contribute the bulk of a lake or reservoir deposit." (Einstein, H. A., and Chien, N., 1953, Transport of sediment mixtures with large ranges of grain sizes: Mo. River Development Series no. 2, Univ. of Calif. Institute Engineering Research, p. 31.)

"The wash load consists of fine particles, usually of the silt and clay sizes, of which there is very little in the stream bed." (Vanoni, V. A., and Brooks, N. H., 1957, Laboratory studies of the roughness and suspended load of alluvial streams: Final Report to Corps of Engineers, U. S. Army, Mo. River Div., contract VA-25-075-eng-3866, p. 68.)

"Wash load is the part of the total sediment load consisting of particles whose sizes are finer than those present in significant quantities in the bed. In this report, wash load includes all sizes finer than the largest standard separation size, at which no more than 10 percent of the bed material is finer." (Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 10.)

BEDLOAD

Proposed Definition

Bedload.--The sediment that moves by sliding, rolling or bouncing on or very near the streambed; sediment moved mainly by tractive or gravitational forces, or both, but at velocities less than the surrounding flow.

Discussion

A definition which includes "the physics of motion of the system" seems mandatory.

Text Books

"Sediments transported by traction are usually termed bedload." (Twenhofel, W. H., 1950, Principles of sedimentation: New York, McGraw-Hill, 2d ed., p. 202.)

Glossaries and Dictionaries

"Bedload. Soil, rock particles or other debris rolled along the bottom of a stream by the moving water, as contrasted with the 'silt load' carried in suspension." (AGI Glossary.)

Scientific Journals

"Bedload is that part of the total sediment-load conposed of all particles greater than a limiting size (42-mesh sieve for the Enoree River) whether moving on the bed or in suspension, and includes all bed-material in movement." (Einstein, H. A., Anderson, A. G., and Johnson, J. W., 1940, A distinction between bed-load and suspended load in natural streams: Am. Geophys. Union Trans.: pt. II, 21st Ann. Mtng., p. 632.)

"Some years ago the term 'geschiebe' was introduced into American engineering practice from the German. This term means 'that which is shoved.' Its meaning is synonymous with 'bed load.' Since it failed to come into general use, although there are many points in its favor, it would probably be unprofitable to try to reintroduce it.

"In order to open up a discussion which it is hoped will lead to a more explicit meaning of the term 'bedload,' the author would like to have consideration given to the following general definitions: Bedload is the coarse sediment which is being moved on or near the bed. Bedload would therefore include the sliding, rolling and saltation load plus the coarser portion of the suspended load, if any is present. It is believed that this definition is in substantial agreement with the more extensive use of the term. Since this proposed definition of 'bedload' includes in it part of the suspended load, the remainder of the load cannot be called 'suspended load,' and it is recommended that the term 'non-bed load' be used."

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"...'Bedload' would be defined as coarse sediment in motion on or near the bed." (Lane, E. W., 1941, Need for standardization of terms used in studies of the transportation and deposition of sediment, in Howe, J. W., ed., Investigations of the Iowa Institute of Hydraulic Research 1939-1940: Univ. of Iowa, Studies in Eng., Bull. 26, p. 11-13.)

"Bedload may be used to designate either coarse material moving on or near the bed, or material collected in or computed from samples collected in a bed load sampler or trap." (Lane, E. W., Chm., 1947, Report of the subcommittee on sediment terminology: Am Geophys. Union Trans., v. 28, p. 936.)

"Bedload. Bed particles moving in the bed layer. This motion occurs by rolling, sliding, and sometimes by jumping." (Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U. S. Dept. Agr. Soil Conserv. Serv. Tech. Bull. 1026, p. 4.)

"The bedload is defined as that part of the load whose normal immersed weight component is in normal equilibrium with the grain stress. This stress is transmitted downwards via the dispersed grains to the stationary grains of the bed upon which it therefore ultimately rests." (Bagnold, R. A., 1956, The flow of cohesionless grains in fluids: Royal Soc. [London] Philos. Trans., v. 249, p. 250.)

U. S. Government Publications

"Bedload is that part of the solids load of the stream which is moving in almost continuous contact with the stream bed, being rolled or pushed along the bottom by the force of the moving water." (Inter-Agency Report no. 2, 1940, Equipment used for sampling bed-load and bed material: Washington, U. S. Govt. Printing Office, p. 10.)

"Bedload...only that part of the sediment load need be considered that can take part in changes in the conformation of the bed by deposition or scour. This part of the moving sediment, at least temporarily, has been and again will be part of the stream bed. This material, for the purpose of this discussion, is considered as 'bed load' and defined as 'bed material in movement.' According to this definition, the net deposition or scour in a reach of a river is the difference between the bedload transportation of the upper and lower ends of the reach." (Einstein, H. A., 1944, Bed-load transportation in Mountain Creek: U. S. Dept. of Agr. Soil Conserv. Serv. Tech. Publ. 55, p. 2.)

"Bedload is that part of the sediment load which is in almost continuous contact with the stream bed and is being rolled or pushed along by the force of the moving water." (Love, S. K., and Benedict, P. C., 1948, Discharge and sediment loads in the Boise River drainage basin, Idaho: U. S. Geol. Survey Water-Supply Paper 1048, p. 20.)

"Bedload or sediment discharged as bedload is the sediment that is moved along in essentially continuous contact with the stream bed." (Colby, B. R., and Hembree, C. H., 1955, Computations of total sediment discharge Niobrara River near Cody, Nebraska: U.S. Geol. Survey Water-Supply Papers 1357 [p. 6], 1373 [p. 37] and 1476 [p. 10].)

"Bedload is the sediment that moves by sliding, rolling, or skipping on or very near the streambed and is supported mainly by the bed rather than by the turbulence of the flow." (Colby, B. R., 1961, Effect of depth of flow on discharge of bed material: U.S. Geol. Survey Water-Supply Paper 1498-D, p. 2.)

SALTATION LOAD

Proposed Definition

Saltation Load.--Sediment bouncing along the streambed by the impact of the flow or moved directly or indirectly by the impact of the bouncing particles--sediment particles which move in suspension for very short periods of time.

Early Sources

"...if the bed is uneven, the particle usually does not retain continuous contact but makes leaps, and the process is then called saltation, an expressive name introduced by McGee (GSA Bull., v. 19, p. 199). With swifter current leaps are extended, and if a particle thus freed from the bed be caught by an ascending portion of a swirling current its excursion may be indefinitely prolonged. Thus borne it is said to be suspended, and the process by which it is transported is called suspension. There is no sharp line between saltation and suspension, but the distinction is nevertheless important for it serves to delimit two methods of hydraulic transportation which follow different laws." (Gilbert, G. K., 1914, The transportation of debris by running water: U.S. Geol. Survey Prof. Paper 86, p. 15.)

Scientific Journals

"Saltation load. The sediment bouncing along the bed, or moved, directly or indirectly, by the impact of the bouncing particles." (Subdivision of bedload.) (Lane, E. W., Chm., 1947, Report of the subcommittee on sediment terminology: Am. Geophys. Union Trans., v. 28, p. 936.)

Text Books

"Saltation is a mode of transport in which particles bounce along the stream bed in a series of short interrupted leaps." (Krumbein, W. C., and Sloss, L. L., 1951, Stratigraphy and sedimentation: San Francisco, W. H. Freeman & Co.)

U. S. Government Publications

"Saltation load. Sediment which moves in a series of low arcs ending at the stream bed." (Inter-Agency Report no. 8, 1948, Measurement of the sediment discharge of streams: Washington, U. S. Govt. Printing Office, p. 17.)

TRACTION LOAD

Proposed Definition

Traction Load.--Sediment being dragged or swept along in essentially continuous contact with the streambed.

Discussion

Material involved spatially is the same in both contact and traction load; the latter term connotes a reason for movement occurring.

Early Sources

"In other transportation, including saltation, rolling, and sliding, the efficient factor is motion parallel with the bed and close to it. This second division of current transportation is called by French engineers entrainment but has received no name in English. Being in need of succinct title, I translate the French designation, which indicates a sweeping or dragging along, by the word traction." (Gilbert, G. K., 1914, The transportation of debris by running water: U.S. Geol. Survey Prof. Paper 86, p. 15.)

Text Books

"Traction and suspension are physical methods of transportation that depend upon current velocity and turbulent movement for ability to transport all particles above colloidal dimension. Sediments transported by traction are usually termed bedload." (Twenhofel, W. H., 1950, Principles of sedimentation: New York, McGraw-Hill, 2d ed., p. 202.)

"Traction involves the partial support of the material being transported by the buoyancy of the water or air but consists chiefly of the rolling, pushing, and dragging along of rock particles which are too large to be lifted into the main body of the stream or current." (Thornbury, W. D., 1954, Principles of geomorphology: New York, John Wiley & Sons, p. 48.)

BED LAYER

Proposed Definition

Bed Layer.--A flow layer through which the bedload moves. The thickness of the layer is usually specified in terms of grain diameters.

U. S. Government Publications

"Bed layer. A flow layer, 2 grain diameters thick, immediately above the bed." (Einstein, H. A., 1950, The bed-load function for sediment transportation in open channel flows: U. S. Dept. Agr. Soil Conserv. Service Tech. Bull. 1026, p. 4.)

DISCHARGE

Proposed Definition

Discharge.--In its simplest concept discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe or from a drainage basin. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal or stream into a lake, a stream, or an ocean.

The data in the reports of the Geological Survey on surface water represent the total fluids measured. Thus, the terms discharge, streamflow, and runoff represent water with the solids dissolved in it and the sediment mixed with it. Of these terms, discharge is the most comprehensive. The discharge of drainage basins is distinguished as follows:

Yield.--Total water runout or crop; includes runoff plus underflow.

Runoff.--That part of water yield that appears in streams.

Streamflow.--The actual flow in streams, whether or not subject to regulation, or underflow.

Each of these terms can be reported in total volumes (such as acre-feet) or time rates (such as cubic feet per second or acre-feet per year). The differentiation between runoff as a volume and streamflow as a rate is not accepted.

(Langbein, W. B., and Iseri, K. T., 1960, General introduction and hydrologic definitions: U. S. Geol. Survey Water-Supply Paper 1541-A, p. 7-8.)

Early Sources

"Discharge. The quantity of water passing through any cross section of a stream in a unit of time is the discharge of the stream at that point. It is measured in cubic feet per second, ft^3/sec." (Gilbert, G. K., 1914, The transportation of debris by running water: U.S. Geol Survey Prof. Paper 86, p. 35.)

Glossaries and Dictionaries

"Discharge. Rate of flow at a given instant in terms of volume per unit of time." (AGI Glossary.)

Scientific Journals

"(Discharge) A term for the amount of material moved in a unit of time--The term for amount of material moved in unit time should be 'discharge.' Where this might lead to confusion with water discharge, it should be qualified as for example, sediment discharge, or saltation load discharge." (Lane, E. W., Chm., 1947, Report of the subcommittee on sediment terminology: Am. Geophys. Union Trans., v. 28, p. 937.)

U. S. Government Publications

"Discharge. The amount of water flowing in a channel expressed as volume per unit of time." (Leopold, L. B., and Maddock, T., Jr., 1953, The hydraulic geometry of stream channels and some physiographic implications: U.S. Geol. Survey Prof. Paper 252, p. iv.)

"Discharge (water). Water discharge is the discharge of natural water of a stream. The natural water contains both dissolved solids and suspended sediment." (Colby, B. R., and Hembree, C. H., 1955, Computations of total sediment discharge Niobrara River near Cody, Nebraska: U.S. Geol Survey Water-Supply Paper 1357, p. 7.)

"Discharge (water). Water discharge of a stream is the flow of the stream and includes the sediment and dissolved solids that are contained in the water." (Colby, B. R., Hembree, C. H., and Rainwater, F. H., 1956, Sedimentation and chemical quality of surface waters in the Wind River Basin, Wyoming: U.S. Geol. Survey Water-Supply Paper 1373, p. 38.)

"Discharge (water). Water discharge is the rate of flow of a stream and includes the fluvial sediment and dissolved solids that are transported in the water." (Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 8.)

SEDIMENT DISCHARGE

Proposed Definition

Sediment Discharge.--The quantity (generally dry weight) of sediment transported through a stream cross section in a unit of time.

U. S. Government Publications

"Sediment discharge. Weight of sediment transported per unit of time." (Inter-Agency Report no. 1, 1940, Field practice and equipment used in sampling suspended sediment: Washington, U. S. Govt. Printing Office, p. 20.)

"Sediment discharge. The rate at which dry weight of sediment passes a section of a stream or the quantity of sediment, as measured by dry weight, or by volume, that is discharged in a given time." (Colby, B. R., Hembree, C. H., and Jochens, E. R., 1953, Chemical quality of water and sedimentation in the Moreau River drainage basin. U.S. Geol. Survey Circ. 270 [as quoted by Langbein, W. B., and Iseri, K. T., 1960: U.S. Geol. Survey Water-Supply Paper 1541-A].)

"Sediment discharge is (a) rate at which dry weight of sediment passes a section of a stream or (b) quantity of sediment, as measured by dry weight or by volume, that is discharged in a given time." (Colby, B. R., Hembree, C. H., and Rainwater, F. H., 1956, Sedimentation and chemical quality of surface waters in the Wind River Basin, Wyoming: U.S. Geol. Survey Water-Supply Paper 1373, p. 37.)

"Discharge, as applied to sediment movement, is a time rate of transportation of dry weight of sediment through a cross section." (Colby, B. R., 1961, Effect of depth of flow on discharge of bed material: U.S. Geol. Survey Water-Supply Paper 1498-D, p. 2.)

OBSERVED SEDIMENT DISCHARGE

Proposed Definition

Observed Sediment Discharge.--The rate of total sediment transport determined from observed suspended-sediment concentration and particle size, velocity distribution, stream depth, water temperature and bed sediment size. The total sediment discharge through a cross section.

Discussion

See Discussion following Proposed Definition of Observed Coarse Sediment Discharge.

U. S. Government Publications

"Total sediment discharge or total sediment load is the sum of the suspended-sediment discharge and the bed-load discharge. It is the total quantity of sediment, as measured by dry weight or volume, that is discharged during a given time." (Colby, B. R., and Hembree, C. H., 1955, Computations of total sediment discharge Niobrara River near Cody, Nebraska: U.S. Geol. Survey Water-Supply Paper 1357, p. 6.)

"Total sediment discharge or load is the weight of all the sediment passing a section in a unit time. It is also a product of the total sediment concentration, the total water discharge, and a constant for converting the units to a weight per unit time--generally tons per day." (Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 10.)

"The total sediment discharge through the cross section is obtained by adding the total sediment discharges for all size ranges of the transported sediment. The particle-size distribution of the computed total sediment discharge can be determined from the sediment discharge, the difference between the measured suspended-sediment discharge and the total sediment discharge, and its size distribution can also be computed from the results of the computations of total sediment discharge." (Colby, B. R., and Hubbell, D. W., 1961, Simplified methods for computing total sediment discharge with the modified Einstein procedure: U.S. Geol. Survey Water-Supply Paper 1593, p. 12.)

"The total suspended-sediment discharge is computed from the measured suspended-sediment discharge and the theoretical distribution of velocity and suspended sediment in the vertical. (Colby, B. R., and Hubbell, D. W., 1961, Simplified methods for computing total sediment discharge with the modified Einstein procedure: U.S. Geol. Survey Water-Supply Paper 1593, p. 10.)

OBSERVED SUSPENDED SEDIMENT DISCHARGE

Proposed Definition

Observed Suspended Sediment Discharge.--The rate of suspended sediment transport determined from observed suspended sediment concentration, velocity distribution and stream depth.

Discussion

In the interest of clarity, the subject heading and definition is intended to replace the so-called "measured suspended-sediment discharge." "Measured sediment discharge" has been omitted because it is misleading with respect to accuracy for both clay and silt fractions in the unsampled zone and because it may be considered as negative in concept. The observed suspended sediment discharge may be determined from concentrations from either depth- or point-integrated samples; and velocity and depth data (stream flow measurements). See Discussion following Observed Coarse Sediment Discharge.

U. S. Government Publications

"Measured suspended-sediment discharge is the suspended-sediment discharge that can be computed from water discharge and the concentration of depth-integrated samples.

"Unmeasured sediment discharge or unmeasured sediment load is the difference between total sediment discharge and measured suspended-sediment discharge." (Colby, B. R., and Hembree, C. H., 1955, Computations of total sediment discharge Niobrara River near Cody, Nebraska: U.S. Geol. Survey Water-Supply Paper 1357, p. 6.)

"Unmeasured sediment discharge is the difference between the measured sediment discharge at a cross section and the total sediment discharge at that station. It includes the bed-load discharge and part of the suspended-sediment discharge that is transported between the stream bed and the lowest point of travel of a suspended-sediment sampler." (Colby, B. R., 1956, Relationship of sediment discharge to streamflow: U.S. Geol. Survey open-file report, p. 9.)

"Measured suspended-sediment discharge is the sediment discharge that can be computed directly from the water discharge and the concentration of depth-integrated sediment samples. The water discharge includes not only the water discharged through the sampling zone but also the water discharged below the sampled zone.

"Unmeasured sediment discharge is the difference between the total sediment discharge of a stream and the measured suspended-sediment discharge. It includes sediment that is discharged as bed load and part of the suspended sediment that is discharged below the sampling zone." (Colby, B. R., Hembree, C. H., and Rainwater, F. H., 1956, Sedimentation and chemical quality of surface waters in the Wind River Basin, Wyoming: U.S. Geol. Survey Water-Supply Paper 1373, p. 38.)

"Measured suspended-sediment discharge or load is a rate of sediment movement and is computed as the product of the measured suspended-sediment concentration, the total water discharge, and a constant for converting the units to a weight per unit time generally tons per day. Because the total water discharge is used in the computation, the measured suspended-sediment discharge includes not only the discharge of suspended sediment in the sampled zone but also a part of the discharge of suspended sediment in the unsampled zone.

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"Suspended-Sediment discharge measurement is a determination of suspended-sediment discharge that is made from sufficient suspended-sediment samples at a cross section to define the mean concentration within the sampled zone and from an adequately determined water discharge.

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"Unmeasured sediment discharge or load is the difference between total sediment discharge and the measured suspended-sediment discharge. More particularly, it is the sum of the bed-load discharge and the product of the water discharge in the unsampled zone, a constant for converting the units to a weight per unit time, and the difference between the mean concentrations of suspended sediment in the unsampled and sampled zones." Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 9.)

OBSERVED COARSE SEDIMENT DISCHARGE

Proposed Definition

Observed Coarse Sediment Discharge.--The rate of suspended sediment transport of grain sizes found in significant quantities in the streambed as determined from observed suspended sediment concentration, particle size, velocity distribution, stream depth, water temperature and particle size of bed sediment; the bed sediment discharge of a stream.

Discussion

The terms "observed sediment discharge," "observed suspended sediment discharge" and "observed coarse sediment discharge" are proposed in order to permit distinguishing between (1) transport rates, based on specific field observations, especially including sediment concentrations, and (2) transport rates based largely on hydraulic data and theoretical or empirical formulae.

Observed discharge rates as applied to sediment movement are based on field observations which include determinations of suspended sediment concentrations and such theoretical applications as the modified Einstein method or other methods involving similar field observations. Concentrations of the clay and silt fractions from depth-integrated samples are representative of the stream depth. Concentrations of the sand fraction in the sampled zone is generally less than the actual concentration for the stream depth. Concentrations from depth-integrated samples are considered to be representative of the mean in the stream vertical when used to determine suspended sediment loads. The error introduced depends upon the slope of the concentration gradient for the sand fraction.

Computed discharge rates as applied to sediment movement are based primarily on theoretical formulae using area of cross section, bed-material particle size, and water surface slope or mean velocity, but no observed concentrations. Existing formulae such as that presented by Einstein, Meyer-Peter and Muller, Professional Paper in press by B. R. Colby, and others are in current use.

U. S. Government Publications

"It is recognized at the outset that the unmeasured bed load is of importance and that its omission from the available data is a limitation to the conclusions which may be drawn." (Leopold, L. B., and Maddock, T., Jr., 1953, The hydraulic geometry of stream channels and some physiographic implications: U.S. Geol. Survey Prof. Paper 252, p. 2.)

"Bed-material discharge or load is the part of the total sediment load consisting of particles whose sizes are the same as those present in significant quantities in the bed. In this report, bed-material load includes all material coarser than the largest standard separation size, at which no more than 10 percent of the bed material is finer." (Hubbell, D. W., and Matejka, D. Q., 1959, Investigations of sediment transportation Middle Loup River at Dunning, Nebraska: U.S. Geol. Survey Water-Supply Paper 1476, p. 10.)

"Measured discharge of bed material is the discharge of bed material that can be determined from streamflow and depth-integrated sediment samples, which generally are obtained by sampling the flow from the water surface to within 0.3 or 0.4 foot of the streambed.

"Total discharge of bed material is the discharge of all the bed material that passes through a stream cross section." (Colby, B. R., 1961, Effect of depth of flow on discharge of bed material: U.S. Geol. Survey Water-Supply Paper 1498-D, p. 2.)

AGGRADATION AND DEGRADATION

Proposed Definitions

Aggradation.--A depositional process that increases the elevation of a streambed in a specified reach relative to a previous elevation.

Degradation.--An erosional process that decreases the elevation of a streambed in a specified reach relative to a previous elevation.

Early Sources

"Whenever and wherever a stream's capacity is overtaxed by the supply of debris brought from points above a deposit is made, building up the bed. If the supply is less than the capacity, and if the bed is of debris, erosion results. Through these processes streams adjust their profiles to their supplies of debris. The process of adjustment is called gradation; a stream which builds up its bed is said to aggrade and one which reduces it is said to degrade.

"An alluvial stream is usually an aggrading stream also." (Gilbert, G. K., 1914, The transportation of debris by running water: U.S. Geol. Survey Prof. Paper 86, p. 219.)

Text Books

"In some places channel aggradation is a local phenomenon resulting from backfilling of sediment behind obstructions in the channel, such as fallen trees. The stream would be capable of passing through the sediment load delivered to it if these obstructions were periodically removed. In many watersheds, however, the present rate of coarse sediment production exceeds the stream's capacity to deliver this part of its load to its mouth and general aggradation is resulting...

"In some watersheds where the load is largely fine and carried in suspension, the flood-plain surface is aggrading while the channel bed remains constant or is being degraded. This condition is, of course, decreasing the stage and area of inundation for a given flood discharge.

"Reservoirs upset the regimen of alluvial-bed rivers, causing aggradation of channels upstream and degradation downstream. ...for example, an aggraded channel condition can be traced to bed scour upstream induced by construction of Hoover Dam which desilted the river flow." (Trask, P. D., ed., 1950, Applied sedimentation: New York, John Wiley & Sons, p. 393.)

Scientific Journals

"The formation of reservoir deltas and possible aggradation in the backwater reach above results from deposition as the power of the stream to transport sediment is reduced. Degradation downstream depends on the ability of the stream to erode the bed and banks and to transport the eroded material, and, finally, the regimen of the stream in its lower reaches will depend on the ability of the regulated flows to transport the sediments brought in by tributaries." (Bondurant, D. C., 1952, Sediment investigations for Missouri River projects: Proc. 5th Hydraulics Conf., State Univ. of Iowa, p. 34.)

Glossaries and Dictionaries

"Aggradation. (1) In geology, the natural filling up of the bed of a water-source by deposition of sediment. (2) Specifically, the building up by streams in arid regions of fan-like graded plains, by reason of the shifting streams and the loss of the water in the dry soil. Contrasted with degradation.

"Degradation. The general lowering of the surface of the land by erosive processes, especially by the removal of material through erosion and transportation by flowing water." (Rice, C. M., 1940, Dictionary of geological terms: Ann Arbor, Michigan, Edwards Brothers.)

"Aggrade

"1. 'So long as deposition on the flood plain kept pace with the deposition in the channel, both would rise, but their relation to each other would not be altered. The valley bottom would be built up steadily; or, if we may coin a word to designate a process for which a name is needed, the valley bottom would be aggraded.' (Salisbury, R. D., New Jersey Geol. Survey, p. 103, 1893.)

"2. It is therefore suggested, in accordance with Davis' original proposal that 'graded' be used specifically for the stream in which equilibrium is maintained, and that 'degrading' and 'aggrading' be restricted to cases of the shifting equilibrium. 'Degrading' is down cutting approximately at grade, in contradistinction to such self-explanatory terms as trench or incise. 'Aggrading' is upbuilding approximately at grade. 'Regrading' refers to alteration in the form of the longitudinal profile by simultaneous aggrading and degrading in different parts. The term 'degrade' is still available, of course, to describe the modeling of waste slopes in interstream areas.

"There is no justification or need for using either 'aggrade' or 'degrade' to describe short-period variations in stream activity, that is, as synonyms for filling or scouring (of a channel), or for the more general terms erosion and deposition. (Mackin, J. Hoover, GSA, v. 59, p. 478, 1948)" (As given by AGI Glossary.)

"Aggradation. Modification of the earth's surface in the direction of uniformity of grade, or slope, by deposition, as in a river bed." (Webster)

"Degradation. 4. A wearing down by erosion." (Webster)

SCOUR

Proposed Definition

Scour.--The enlargement of a flow section by the removal of material composing the boundary through the action of the fluid in motion. (Laursen, E. M., 1957, An investigation of the total sediment load: Final report to the Office of Naval Research, Navy Dept., Washington, contract N80nr-500(02), p. 179.)

Discussion

Implicit in this definition is the fact that the moving fluid exerts forces on the particles composing the boundary, causing their movement.

Text Books

"Localized scour and deposition. Systematic experiments upon the rate of scour of a sediment bed by a vertical jet of clear water have indicated the following essential facts:

"(a) The depth of scour in uniform material is dependent solely upon the size and velocity of the jet, the fall velocity of the sediment, and the duration of the scouring action.

"(b) The relative rate of scour produced by a given jet at a given stage depends only upon the ratio of jet velocity to fall velocity, approaching zero as this ratio approaches unity...

"(c) Selective sorting of graded material occurs, so that with a wide variation in size of bed material the bottom of the hole gradually becomes paved with a progressively coarser material, thus decreasing the effective fall velocity of the sediment and reducing the scour rate...

"(d) If sediment is carried in by the jet at exactly the rate at which a clear jet would scour, the scour hole will be stabilized; by interference, an increase in the rate of sediment inflow would cause a reversal in the scour process (i.e., deposition) and hence gradual filling of the hole until equilibrium is again established." (Brown, C. H., 1950, Sediment transportation, in Rouse, H., Engineering hydraulics: New York, John Wiley & Sons, p. 787.)

Glossaries and Dictionaries

"Scour. The cleansing or clearing action of a current of water. Technically, the downward erosion of a stream through its alluvium during floods." (Rice, C. M., 1940, Dictionary of geological terms: Ann Arbor, Michigan, Edwards Brothers, p. 364.)

"Scour and fill. 1.'A stream at flood may be deepening (degrading) its channel, where its velocity is great, at the same time that it is building (aggrading) its flood plain where the velocity is slight. After the flood has subsided the channel thus deepened may be entirely filled with sediment. This process is called scour and fill.' (Cleland, H. F., Geology, Phys. and Hist., p. 89, 1916) 2. The process of cutting and refilling channels in sediments, by which nuggets and other placer particles are redistributed. (Emmons, p. 347, 1940)" (AGI Glossary.)

"Scour depression. 'Where the channel of a stream is curved, the swiftest thread of the current is near the outside of the bend. The maximum erosive force of the current is exerted over a crescentic area in the bend... These areas are likely to be scoured below the grade of the stream, producing the hollows here called scour depressions.' (Bryan, K., Am. Jour. Sci., 4th ser., vol. 50, p. 191, 1920)" (AGI Glossary.)

U. S. Government Publications

"Scour.--Net removal of sediment from stream boundary by action of fluid flow. Scour may be measured in volume of sediment removed from a channel reach, in average depth of sediment removal from an area, in average change of depth at a cross section, or in change of depth at a point." (Colby, B. R., 1964, Scour and fill in sand-bed streams: U.S. Geol. Survey Prof. Paper 462-D, p. iv.)

FILL

Proposed Definition

Fill.--The reduction of a flow section by the deposition of material through the action of the fluid in motion.

Glossaries and Dictionaries

"Fill. 1. 'The withdrawal of the (river) current from the outer side of the curve leaves that bank bordered by quiet water, in which deposition will probably result. Such deposition may be called a fill.' (Tower, W. S., Bull. Am. Geog. Soc., v. 36, p. 593, 1904)" (Taken from AGI Glossary.)

U. S. Government Publications

"Fill.--Net deposition of sediment on stream boundary. Fill may be measured in volume of sediment added to a channel reach, in average depth of sediment accumulation over an area, in average change of depth at a cross section, or in change of depth at a point." (Colby, B. R., 1964, Scour and fill in sand-bed streams: U.S. Geol. Survey Prof. Paper 462-D, p. iv.)

KOLK

Proposed Definition

Kolk.--A form of large scale vortex action, capable of local streambed erosion, which is induced by the upward displacement of a body of water.

Discussion

"Ripple wake suspension" is a possible alternative term for this phenomenon. "Kolk" is preferred because it is not as cumbersome as "ripple wake suspension," is amenable to plural formations and (at least in Dutch) its meaning is implied by the term itself.

Scientific Journals

"...the water was flowing on a bed of sand and was clear...the sand-bed was in ripples, which consisted of a series of small bars scattered irregularly over the bed of the stream with relatively flat upstream slope and steep downstream slope... The phenomena consisted of an upward-moving turbulent current which started from a point on the downstream-sloping face of the ripple and carried the bed-material upward. This turbulent current extended to the surface, where it spread out and mixed with the horizontal current of the stream and the sediment carried up with it spread out with the current and gradually settled back to place but remained stationary always rising from the end of the same ripple. It has been suggested by A. A. Kalinske that they are caused by the wake formed behind a sand-ripple on the bed, since they resemble the wake formed behind a ship rather than a vortex." (Lane, E. W., 1944, A new method of sediment-transportation: Am. Geophys. Union Trans., part VI, 25th Ann. Mtg., p. 900.)

"Kolk. Bed deepening by vortex action induced by upward displacement of a body of water is one of the commonest as well as most important forms of macroturbulence in natural streams. ... The writer recommends the adoption of 'kolk' by American engineers, restricting its use, however, to the original Dutch meaning, which denotes bed deepening by vortex suction...

* * * * * * *

"In marked contrast with the continuity of eddying is the spasmodic upward displacement of large volumes of water which induce vortex suction capable of lifting not only bedload materials but of gouging scour holes and potholes into resistant beds. The action is short-lived but frequent, typical of other hydraulic cavitation and lesser suction phenomena. The velocity of rotation at the pointed end of the vortex is of a high order, many times greater than the velocity of the surrounding streamflow. In shallow waters, small kolks are readily studied. They develop weak suction which raises only sand grains and scatters these in the flowing body of the stream; the resulting boil also is weak (Lane, 1944). In deep swift waters, during rising flood stages, the kolk assumes large proportions, develops cavitation, and becomes an important agency in bed-scour and pothole formation. Its lifting force raises bed materials toward the surface with great velocity, entraining gravel and cobblestones from coarse bedloads. The action in clear water and in sediment-laden water is essentially similar. As a fluid-mechanics phenomenon it is in many respects similar to tornadic action, taking into account the differences in viscosity of water and air. As in the tornado, the whirling vortex action of the kolk loses force in the ascent, and much of the entrained material drops out as the upward forces diminish in intensity. Kolks dissipate at the surface in the form of boils in which the water pushed up to the surface flows out radially on top of the flowing prism, carrying with it the finer bottom materials which journeyed to the surface." (Matthes, G. H., 1947, Macroturbulence in natural stream flow: Am. Geophys. Union Trans., v. 28, p. 255.)

EDDY

Proposed Definition

Eddy.--Any rotating fluid motion which possesses continuity so long as the flow pattern which creates it continues to prevail. (Matthes, C. H., 1947, Macroturbulence in natural stream flow: Am. Geophys. Union Trans., v. 28, p. 255.)

Glossaries and Dictionaries

"Eddy. A current of air or water running contrary to the main current, especially one moving in a circle; a whirlpool. (Webster)" (AGI Glossary.)

TURBULENCE

Proposed Definition

Turbulence.--The fluid property that is characterized by irregular variation in the speed and direction of movement of individual particles or elements of the flow as a result of complex secondary motion being superposed upon the primary motion of translation.

Text Books

"A distinguishing characteristic of turbulence is its irregularity, there being no definite frequency, as in wave action, and no observable pattern..." (Daugherty, R. L., and Ingersoll, A. C., 1954, Fluid mechanics: New York, McGraw-Hill, 5th ed., p. 53.)

Glossaries and Dictionaries

"Turbulent flow. That type of flow in which the stream lines are thoroughly confused through heterogeneous mixing of flow. The head loss varies approximately with the second power of the velocity. (After Rouse, Eng. Hydraulics, p. 10, 1947)" (AGI Glossary.)

"Turbulent flow. Fluid flow in which the velocity at a given point changes constantly in magnitude and direction..." (Webster.)

U. S. Government Publications

"Turbulence: The state at any point within a fluid where the direction and magnitude of the velocity vary irregularly with time. In true turbulence, such fluctuations are not periodic but occur entirely at random, their frequency of occurrence following the normal error law." (Inter-Agency Report no. 3, 1941, Analytical study of methods of sampling suspended sediment: Washington, U. S. Govt. Printing Office, p. 21.)

DENSITY CURRENT

Proposed Definition

Density Current.--A gravity flow of a fluid through, under, or over a fluid of approximately equal density. (Bell, H. S., 1942, Density currents as agents for transporting sediments: Jour. Geology, v. 50, p. 513.)

TURBIDITY CURRENT

Proposed Definition

Turbidity Current.--A type of density current consisting of turbid water flowing through, under, or over water of a different density.

Discussion

Density differences in turbidity currents are due largely to the presence of suspended sediment. In some instances, however, temperature or salinity may be the dominant factor or factors.

Text Books

"It has long been recognized that turbid water is, by virtue of the sediment held in suspension, of greater density than the same water when clear; just as saline water is, by virtue of the salt held in solution, of greater density than the same water when pure. Currents resulting from these differences in density belong in the general group of density currents, but need to be distinguished by special names... Those due to turbidity will here be called turbidity currents." (Johnson, D., 1939, The origin of submarine canyons: New York, Columbia Press, p. 27.)

"Density currents arise wherever masses of water differ in specific gravity, the heavier mass flowing under the light which it displaces." (Dunbar, C. O., and Rodgers, J., 1957, Principles of stratigraphy: New York, John Wiley & Sons, p. 13.)

Glossaries and Dictionaries

"Density current. ... 2. Solutions or mixtures of gases or liquids which differ in density from a main body of enclosing fluid by virtue of a difference in temperature or concentration of solute. (Menard and Ludwick, Soc. Econ. Pal. and Min. SP No. 2, p. 2, 1951) 3. A current due to differences in the amount of suspended matter in a fluid. (After SEPM SP No. 2, p. 3, 1951)" (AGI Glossary.)

Scientific Journals

"Density current=turbidity current. 1. A highly turbid and relatively dense current which moves along the bottom slope of a body of standing water. It may also occur as an underflow in a lake or reservoir, a dust storm, or a descending cloud of volcanic dust." (Bell, H. S., 1942, Density currents as agents for transporting sediments: Jour. Geology, v. 50, p. 513.)

"Simple experiments can be made in the laboratory to show that water of greater specific gravity is obtained by decrease in temperature, the solution of soluble materials, or the suspension of solid material of such fineness that it will stay in suspension for several hours, will find its way to the bottom of a dish containing water of less specific gravity. If there is any flow of water in the dish, the water of greater specific gravity will move along the bottom to the outlet." (Grover, N. C., and Howard, C. S., 1938, The passage of turbid water through Lake Mead: Am. Soc. Civil Engineers Trans., v. 64, p. 730.)

"A turbidity current can be simply defined as a current that carries fine-grained sediment in suspension." (Smith, W. O., Vetter, C. P., Cummings, G. P., and others, 1960, Comprehensive survey of sedimentation in Lake Mead: U.S. Geol. Survey Prof. Paper 295, p. 201.)

"... Thus, a turbidity current can be defined as a gravity flow of turbid water through, under, or over water of different density. Part of the difference in density is produced by the suspended sediment, but suspended sediment is not always the dominant factor. In the overflow type of turbidity current, the lower density is due to higher temperature or lower salinity or both. Similarly, in the interflow or underflow type of current, suspended sediment may not account in some cases for as great a part of the higher density as does lower temperature or higher salinity." (Smith, W. O., Vetter, C. P., Cummings, G. P., and others, 1960, Comprehensive survey of sedimentation in Lake Mead: U.S. Geol. Survey Prof. Paper 295, p. 201.)

TEXTURAL CLASSIFICATION

Proposed Definition

Textural Classification.--

Class Name	Particle Size (mm)	General Methods of Determination
Boulders	>256	Manual measurement of desired diameter
Cobbles	64-256	Ditto
Very coarse gravel	32-64	Ditto
Coarse gravel	16-32	
Medium gravel	8-16	Sieves
Fine gravel	4-8	
Very fine gravel	2-4	
Very coarse sand	1-2	Visual accumulation tube, sieves
Coarse sand	0.5-1	
Medium sand	0.25-0.5	
Fine sand	0.125-0.25	
Very fine sand	0.062-0.125	
Silt	0.004-0.062	Pipette, bottom withdrawal tube, hydrometer
Clay	<0.004	

(Class name and particle size taken from: Lane, E. W., Chm., 1947, Report of the subcommittee on sediment terminology: Am. Geophys. Union Trans., v. 28, p. 937.)

NOMINAL DIAMETER

Proposed Definition

Nominal Diameter.--The diameter of a sphere that has the same volume as the particle. (After Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 11.)

SIEVE DIAMETER

Proposed Definition

Sieve Diameter.--The length of the side of the smallest square opening through which the given particle will pass. (After Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 11.)

STANDARD FALL DIAMETER OR FALL DIAMETER

Proposed Definition

Standard Fall Diameter or Fall Diameter.--The diameter of a sphere which has a specific gravity of 2.65 and the same standard fall velocity as the particle in question. (After Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 11.)

SEDIMENTATION DIAMETER

Proposed Definition

Sedimentation Diameter.--The diameter of a sphere that has the same specific gravity and the same terminal uniform settling velocity as the given particle in the same sedimentation fluid. (After Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 11.)

STANDARD SEDIMENTATION DIAMETER

Proposed Definition

Standard Sedimentation Diameter.--The diameter of a sphere that has the same specific gravity and the same standard fall velocity as the given particle. (After Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 11.)

SIZE DISTRIBUTION

Proposed Definition

Size Distribution.--The variation of particle diameters by infinitesimals along the entire range of particle sizes present; but usually, specified in terms of the weight of sediment in finite size groups in accordance with a specified textural classification.

U. S. Government Publications

"Size-distribution, or simply distribution, when applied in relation to any of the size concepts, will sepcify frequency by weight rather than by particle count." (Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 11.)

PARTICLE SHAPE OR SPHERICITY

Proposed Definition

Particle Shape or Sphericity.--The ratio of the surface area of a sphere to that of the particle in question, both having the same volume.

$$\text{Ideally, sphericity} = \frac{s}{S}$$

where

s = surface area of a sphere of the same volume as the fragment in question.

S = the actual surface area of the particle in question.

$$\text{For practical purposes, sphericity} = \frac{d_n}{D_s}$$

where

d_n = nominal diameter (diameter of a sphere of the same volume as the object--determined by dropping the object in a graduated cylinder and noting the volume of water displaced).

D_s = diameter of circumscribed sphere (usually the longest diameter of the object).

(Essentially from: Krumbein, W. C., and Pettijohn, F. J., 1938, Manual of sedimentary petrography: New York, Appleton-Century-Crofts, Inc., p. 292.)

PARTICLE ROUNDNESS

Proposed Definition

Particle Roundness.--The relative sharpness of the edges and corners of a clastic fragment which is independent of shape or sphericity. For simplicity, the projection of a particle may be used, then:

$$\text{Particle Roundness, } \rho = \frac{\Sigma \gamma_i}{RN}$$

where

γ_i = individual radii of the corners of the particle.

R = radius of the maximum inscribed circle.

N = number of corners measured.

(Essentially from: Krumbein, W. C., and Pettijohn, F. J., 1938, Manual of sedimentary petrography: New York, Appleton-Century-Crofts, Inc., p. 298.)

SHAPE FACTOR (SEDIMENT)

Proposed Definition

Shape Factor (Sediment).--An arbitrary ratio of the lengths of three mutually perpendicular axes of a sediment particle.

$$\text{Shape Factor, S.F.} = \frac{c}{\sqrt{ab}}$$

where

a = longest axis.

b = intermediate axis.

c = shortest of the three mutually perpendicular axes of the particle.

(After Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 18.)

STANDARD FALL VELOCITY

Proposed Definition

Standard Fall Velocity.--The average rate of fall that a particle would attain if falling alone in quiescent distilled water of infinite extent and at a temperature of 24°C. (After Inter-Agency Report no. 12, 1957, Measurement and analysis of sediment loads in streams--some fundamentals of particle size analysis: Washington, U. S. Govt. Printing Office, p. 11.)

HYDROLOGIC DATA STATION

Proposed Definition

Hydrologic Data Station.--A site at which records pertinent to water resource development are obtained.

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As applied to surface drainage, a hydrologic data station is a particular site or reach of a stream at which observations are made to obtain information on one or more of the following: amount and composition of precipitation; composition and concentration of solutes in the stream; streambed forms; size distribution, concentration, and mineralogy of sediments; stream temperature; types and quantities of aquatic fauna and flora; width, depth, velocity, and slope of water surface of the stream.

SEDIMENT STATION

Proposed Definition

Sediment Station.--A particular site on a stream or canal where a record of sediment discharge is obtained.

U. S. Government Publications

"Sediment station. A river section where samples of suspended load are taken each day, or periodically." (Leopold, L. B., and Maddock, T., Jr., 1953, The hydraulic geometry of stream channels and some physiographic implications: U.S. Geol. Survey Prof. Paper 252, p. IV.)

State Publication

"Sediment Station. One or more cross-sectional planes of a stream, usually normal to mean direction of flow, in which samples are collected on a systematic basis for determination of concentration, particle size distribution, or other characteristics." (Mundorff, J. C., 1961, A program of fluvial sediment investigations in Kansas: State of Kansas Bull. #6, p. 47.)

DEPTH-INTEGRATING SEDIMENT SAMPLER

Proposed Definition

Depth-Integrating Sediment Sampler.--An instrument for the collection of a representative sample of the water-sediment mixture in a stream vertical while moving at approximately a constant rate of travel. The sample may be taken on an upward or downward trip through the vertical or on a round trip. The velocity in the nozzle of the sampler at point of intake is nearly equal to the velocity at every point of its travel.

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(The Geological Survey uses the U.S. DH-48, DH-59 and D-49 depth-integrating samplers. The U.S. point-integrating samplers are also used to collect depth-integrated samples in deep streams [see page 106].)

STREAM VERTICAL

Proposed Definition

Stream Vertical.--The vertical distance from the water surface to the streambed at any observation station in a stream cross section. (See Figure 1.)

U. S. Government Publications

"Vertical. Path taken by a sampler in moving from the water surface to the streambed." (Inter-Agency Report no. 8, 1948, Measurement of the sediment discharge of streams: Washington, U. S. Govt. Printing Office, p. 17.)

"Vertical is a line extending vertically from the surface to the bed of a stream. It is a location at which sediment samples are obtained or other hydraulic measurements are made." (Jordan, P. R., Jones, B. F., and Petri, L. R., 1964, Chemical quality of surface waters and sedimentation in the Saline River Basin, Kansas: U.S. Geol. Survey Water-Supply Paper 1651, p. 84.)

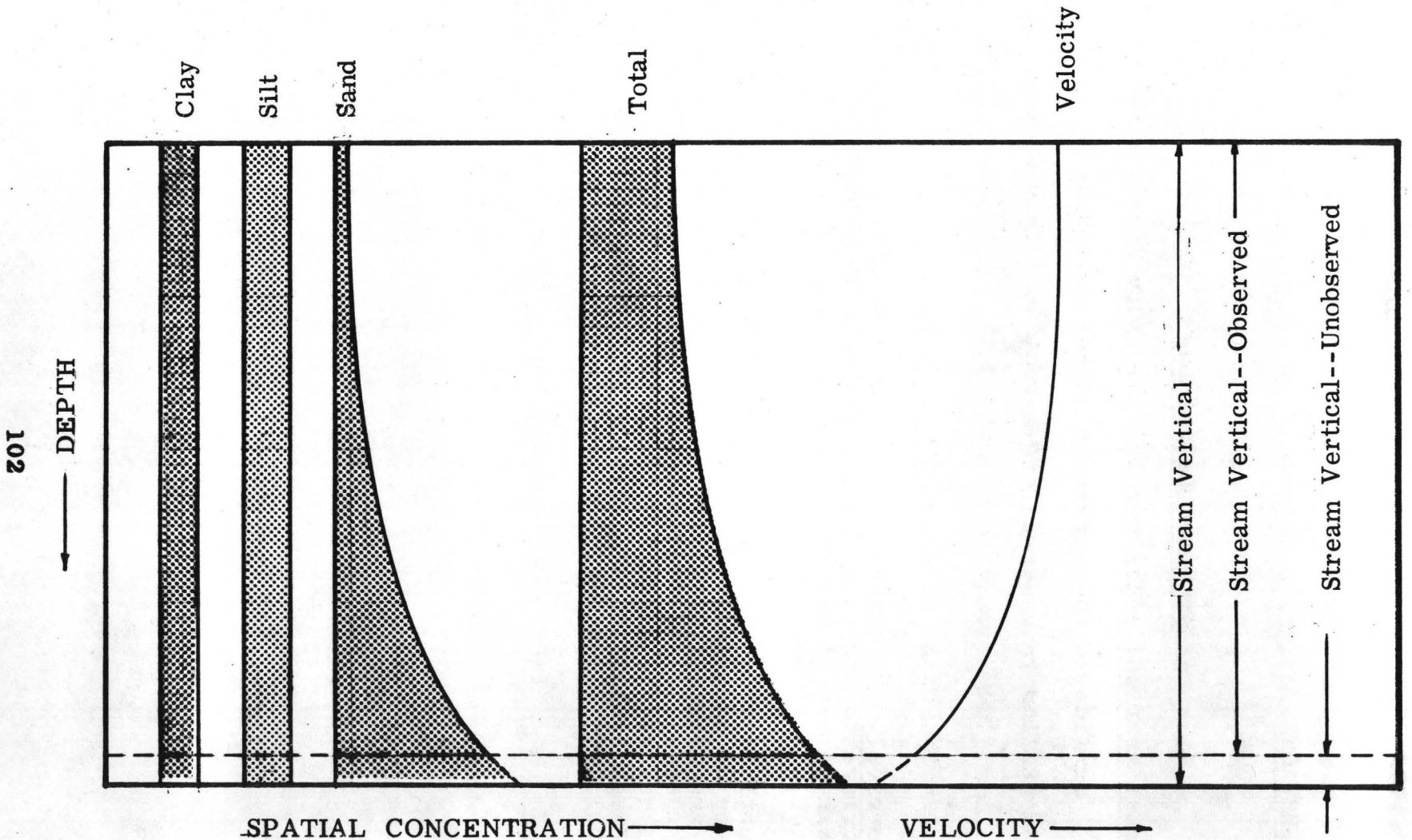

Figure 1.--Diagrammatic sketch depicting sediment and velocity distribution for the observed and unobserved segments of a stream vertical.

STREAM VERTICAL--OBSERVED

Proposed Definition

Stream Vertical--Observed.--That part of the stream vertical from the water surface to a point near the streambed for which velocity and concentration can be observed. (See Figure 1.)

STREAM VERTICAL--UNOBSERVED

Proposed Definition

Stream Vertical--Unobserved.--That part of the stream vertical immediately above the streambed for which velocity and concentration are not normally observed, due to technical limitations. (See Figure 1.)

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(The unobserved segment ranges from 0.4 [rod suspension] to 0.5-1.5 feet [cable suspension] for velocity [Price Current Meter], and 0.3 feet [rod suspension] to 0.4 feet [cable suspension] for concentration. The latter item is increased to 1.8 feet if a 100-pound, C-type sounding weight is attached to a USP-46 sampler.)

DEPTH-INTEGRATION METHOD--NON-UNIFORM SPACING

Proposed Definition

Depth-Integration Method--Non-Uniform Spacing.--A method for determining the mean concentration of the flow by: (1) collecting a sample at a stream vertical at centroids of equal discharge and averaging the concentration of the samples, or (2) collecting samples at selected stream verticals and weighting the concentrations of the samples on the basis of lateral distribution of flow in the cross section. The rate of travel of the sampler can vary between verticals and between upward and downward trips, but it must be uniform for each trip through the flow to obtain a discharge weighted mean concentration from each sample for each vertical.

Discussion

See Discussion following Proposed Definition for Depth-Integration Method--Uniform Spacing.

DEPTH-INTEGRATION METHOD--UNIFORM SPACING

Proposed Definition

Depth-Integration Method--Uniform Spacing.--A method for determining the mean concentration of the flow by collecting samples at stream verticals uniformly spaced in the cross section. The rate of travel of the sampler in a vertical, once selected, must be the same for all verticals to obtain a discharge weighted mean concentration for the cross section by a single analysis of a composite sample.

Discussion

It is necessary to clearly differentiate as to location of sampling verticals and transit rate. The term "equal transit rate method" (ETR) is not only confusing but misleading.

POINT-INTEGRATING SEDIMENT SAMPLER

Proposed Definition

Point-Integrating Sediment Sampler.--An instrument designed to collect a representative sample of the water-sediment mixture at a selected depth in a stream vertical. The intake velocity of the sampler is essentially equal to the stream velocity at that depth.

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(The Geological Survey uses the U.S. P-46, P-61 and P-63 point-integrating samplers to collect point- and depth-integrated samples in deep streams. The DH-48 sampler can be used to collect point-integrated samples in shallow streams, provided certain physical modifications are made, and[or] sampling techniques are changed.)

SEDIMENT TRANSPORT CURVE

Proposed Definition

Sediment Transport Curve.--A graph showing the relation between the water discharge (cfs) and sediment in transport (tons per day or ppm) at a stream cross section.

Discussion

Data on "discharge" includes "sediment discharge" (see Langbein, W. B., and Iseri, K. T., U.S. Geol. Survey Water-Supply Paper 1541-A, p. 7). Hence a plot of discharge (cfs) versus observed suspended sediment discharge (tons/day) cannot be technically described as a "rating curve." Likewise, if we consider transport processes only the sand fraction in the bed is related to the coarse material in transport. In addition, the "cause and effect" relationship or correlation is misleading--a curve of apparent perfect correlation may, in fact, have no real cause and effect. Guy (written communication) has compared "concentration" with "sediment discharge" as a dependent variable in multiple regression analysis of two streams. The use of "sediment discharge" instead of "concentration" not only causes unreasonably high correlation with water discharge, as mentioned, but greatly reduces the significance of other independent variables.

The terms "sediment rating curve," "sediment transport curve" and "sediment discharge curve" have been used by several authors. In terms of processes, the sediment is transported by the water. Hence, "sediment transport" is the most descriptive and, therefore, the most acceptable. (Hubbell, D. W., and Matejka, D. Q., U.S. Geol. Survey Water-Supply Paper 1476, p. 20.)

U. S. Government Publications

"Suspended sediment-discharge curve. A graph of water discharge plotted against concomitant measured suspended-sediment load." (Leopold, L. B., 1953, The hydraulic geometry of stream channels and some physiographic implications: U.S. Geol. Survey Prof. Paper 252, p. IV.)

SPECIFIC WEIGHT

Proposed Definition

Specific Weight.--The ratio of the weight of the solid mineral particles to the volume of the sample, expressed in pounds per cubic foot. (Smith, W. O., and others, 1960, Comprehensive survey of sedimentation in Lake Mead: U.S. Geol. Survey Prof. Paper 295, p. 153.)

Discussion

Specific weight equals density if acceleration due to gravity is assumed constant.

Text Books

"Specific weight. The weight per unit volume of any substance must be computed from the density of the substance and the local magnitude of gravitational acceleration." (Rouse, H., 1946, Elementary mechanics of fluids: New York, John Wiley $ Sons, p. 358.)

"Density. The measurement of mass usually involves comparison of the gravitational attraction exerted upon the body of matter with that exerted upon a reference body of known mass. ... Division of the mass of the body of matter by the volume of the space which it occupies then yields its mass density.

"The density of every liquid varies somewhat with temperature and pressure." (Rouse, H., 1946, Elementary mechanics of fluids: New York, John Wiley & Sons, p. 357.)

"Specific weight (also known as the 'unit dry weight' or 'dry density') is defined as the dry weight per unit volume of the sediment in place." (Brown, C. H., 1950, Sediment transportation, in Rouse, H., Engineering hydraulics: New York, John Wiley & Sons, p. 784.)

"Density...gravitational effects at the interface between two fluids of slightly different density...are closely related to the free-surface phenomena more familiar to the hydraulic engineer. Density differences of this nature can result from variation in temperature, as in the ocean or the atmosphere; from salt-water intrusion, as in tidal estuaries; or from the suspension of finely divided solids, as in dust-laden winds or sediment-laden waters." (Kuelegan, G. H., Wave motion, in Rouse, H., Engineering hydraulics: New York, John Wiley & Sons, p. 756.)

"The density of a fluid is its mass per unit volume while the specific weight is its weight per unit volume....

"Specific weight, w...represents the force exerted by gravity on a unit volume of fluid....

$$\rho = \frac{w}{g} \quad \text{or} \quad w = \rho g$$

where

ρ = density

w = specific weight

g = acceleration due to gravity

(Daugherty, R. I., and Ingersoll, A. C., 1954, Fluid mechanics: New York, McGraw-Hill, p. 2.)

Glossaries and Dictionaries

"Density. The density of a substance is the weight (expressed in grams) of unit volume (one cubic centimetre) of the substance at 4°C. Cf. specific gravity." (Rice, C. M., 1940, Dictionary of geologic terms: Ann Arbor, Mich., Edwards Bros., 102.)

"Density. 1. The mass or quantity of a substance in grams per cubic centimeter." (AGI Glossary.)

"Density. The ratio of the mass of a homogeneous portion of matter to its volume." (Webster.)

U. S. Government Publications

"Specific weight of sediment deposit is weight of solids per unit volume of deposit in place." (Colby, B. R., Hembree, C. H., and Rainwater, F. H., 1956, Sedimentation and chemical quality of surface waters in the Wind River Basin, Wyoming: U.S. Geol. Survey Water-Supply Paper 1373, p. 38.)

"Specific weight, the ratio of the weight of the solid mineral particles to the volume of the sample, is expressed in pounds per cubic foot.

"The density of a sediment deposit is the ratio of the weight of the sediment plus its included water (or, in the more fluid samples, of the water and its included sediment) to the weight of an equivalent volume of water alone. It is recognized that the density of water changes with temperature and these changes are significant factors--for instance, in the development of turbidity currents. However, these are small in comparison with the changes that result when appreciable quantities of mineral particles are added to the water. In the determinations of density of sediment deposits, therefore, it is assumed that the weight-volume ratio of water remains constant." (Smith, W. O., and others, 1960, Comprehensive survey of sedimentation in Lake Mead: U.S. Geol. Survey Prof. Paper 295, p. 153.)

SPECIFIC GRAVITY

Proposed Definition

Specific Gravity.--The ratio between the weight of a body and the weight of an equal volume of water (at 4°C.). (Krumbein, W. C., and Pettijohn, F. J., 1931, Manual of sedimentary petrography: New York, Appleton-Century-Crofts, Inc., p. 501.)

Text Books

"...specific gravity is merely a relative term representing the ratio of its density or specific weight to that of water." (Rouse, H., 1946, Elementary mechanics of fluids: New York, John Wiley & Sons, p. 65.)

"... The specific gravity of quartz is 2.65, and this is generally used as characteristic of sediment as a whole, even though the other constituents of the source material have an average specific gravity which is somewhat lower." (Brown, C. H., 1950, Sediment transportation, in Rouse, H., Engineering hydraulics: New York, John Wiley & Sons, p. 777.)

Glossaries and Dictionaries

"Specific gravity. The ratio of the mass of any quantity of a substance to the mass of an equal volume of some standard substance. In the case of solids and liquids the latter is chosen as water at 4°C. Cf. density." (Rice, C. M., 1940, Dictionary of geological terms: Ann Arbor, Mich., Edwards Bros., p. 384.)

"Specific gravity. Ratio of the mass of a body to the mass of an equal volume of water at a specified temperature." (AGI Glossary.)

"Specific gravity. Because the relative weight of the sediment in the fluid is the desired variable, specific gravity is usually determined instead of density. Considerable variation in specific gravity exists in particles of large size (larger than gravel--4 mm.) because the mineral composition depends upon the parent rock. In nature most sands are composed of quartz (SG = 2.65). Therefore, the specific gravity of sand is approximately 2.65. The fine materials (silt and clay--sizes less than 1/16 mm.) are more often fragments of feldspars and micas (SG = 2.5 to 2.7) and therefore these fine materials tend to have a lower specific gravity." (Schule, E. F., Wilde, R. H., and Albertson, M. L., 1954, Influence of shape on the fall velocity of sedimentary particles: Missouri River Div., Sed. Series no. 55, p. 8.)

SPECIFIC WEIGHT OF WATER-SEDIMENT DISPERSIONS

Proposed Definition

Specific Weight of Water-Sediment Dispersions.--Specific weight of water-sediment dispersions (lb/ft^3). The ratio of the water-sediment mixture to the specific weight of the sediment and reference concentration. It is expressed by the following two equations:

(1) $$\gamma = \frac{\gamma_w \gamma_s}{\gamma_s - 1.03\frac{c}{10^4}}$$

where

γ is the specific weight of the water-sediment dispersion

γ_w is the specific weight of water in lb/ft^3

γ_s is the specific weight of sediment in lb/ft^3

c is the sediment concentration in ppm by weight

(Term $\frac{-1.03\ c}{10^4}$ involves assumption of $\gamma_w = 62.4\ lb/ft^3$

and $\gamma_s = 165.4\ lb/ft^3$)

(After Simons, D. B., and others, 1963, Effects of fine sediment on flow phenomena: U.S. Geol. Survey Water-Supply Paper 1498-G, p. 24.)

(2) $$Sw = \frac{62.43\ W_d}{V_{wa} + \frac{W_d}{sg}}$$

where

Sw = the specific weight of the water-sediment dispersion in lb/ft^3

W_d = weight of dried sample

V_{wa} = volume of interstitial water (determined by oven-drying)

sg = specific gravity of grains

(Smith, W. O., and others, 1960, Comprehensive survey of sedimentation in Lake Mead: U.S. Geol. Survey Prof. Paper 295, p. 153.)

POROSITY

Proposed Definition

Porosity.--The volume percent not occupied by solid material, as expressed by the following equation:

$$\text{Porosity, } P = \frac{100\ V_{wa}}{V_{wa} + \frac{W_d}{sg}}$$

where

V_{wa} = Volume of interstitial water (determined by oven-drying)

W_d = weight of dried sample

sg = specific gravity of grains.

(Smith, W. O., and others, 1960, Comprehensive survey of sedimentation in Lake Mead: U.S. Geol. Survey Prof. Paper 295, p. 153.)

FROUDE NUMBER

Proposed Definition

Froude Number.--Ratio between hydrodynamic and hydrostatic forces. (Von Karman, T., 1942, The role of fluid mechanics in modern warfare: Proc. Second Hydraulics Conf., Univ. of Iowa, p. 24.)

$$\text{Froude number, } F = \frac{V}{\sqrt{gL}}$$

where

V = typical relative velocity

g = acceleration due to gravity

L = a typical dimension.

(Rouse, H., 1950, Engineering hydraulics: New York, John Wiley & Sons, p. 54.)

Discussion

In words, the Froude number has been described as: "...the ratio of a typical velocity head to a typical linear dimension of the flow is a measure of the extent to which gravitational action enters into the flow phenomenon--the higher its magnitude, the smaller the relative effect of gravity and vice versa. A flow parameter of this type is commonly called the Froude number." (Rouse, H., 1950, Engineering hydraulics: New York, John Wiley & Sons, p. 54.)

"F = Froude number = $\frac{U}{\sqrt{gd}}$

"g = gravitational acceleration

"d = mean depth of flow

"U = mean velocity."

(Vanoni, V. A., and Brooks, N. H., 1957, Laboratory studies of the roughness and suspended load of alluvial streams: Final report to Corps of Engineers, U. S. Army, Missouri River Div., p. 116.)

$$\text{"Fr} = \frac{V}{\sqrt{gD}}$$

"Fr = Froude number

"V = average velocity based on continuity principle

"g = acceleration of gravity

"D = average depth of flow."

(Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. 11.)

REYNOLDS NUMBER (FLOW)

Proposed Definition

Reynolds Number (Flow).--Ratio of inertial forces to friction forces, as expressed by:

$$R = \frac{VD}{\nu} = 4\frac{Ur}{\nu}$$

V = average velocity

D = average depth of flow

ν = kinematic viscosity

U = mean velocity

r = hydraulic radius

Discussion

Reynolds number unmodified usually refers to Reynolds number of flow, as defined above; however, it may refer to other parameters also, some of which follow.

Text Books

$$R = \frac{VL}{\nu}$$

"R = Reynolds number

"V = represents a typical relative velocity between fluid and boundary

"L = a typical dimension (i.e., a sphere diameter, a depth of flow, etc.)

"ν = kinematic viscosity of the fluid."

(Rouse, H., 1950, Engineering hydraulics: New York, John Wiley & Sons, p. 83.)

"Reynolds number of flow: Considering the ratio of inertia forces to friction forces, a parameter is obtained called the Reynolds number or the Reynolds law...

$$Nr = \frac{LV}{\nu}$$

"Nr = Reynolds number

"L = Length (for a pipe L usually equals the diameter)

"V = Mean velocity of fluid

"ν = Kinematic viscosity."

(Daugherty, R. L., and Ingersoll, A. C., 1954, Fluid mechanics: New York, McGraw-Hill, p. 100.)

Glossaries and Dictionaries

"'Reynolds Criteria' or 'Number' which, briefly, is a ratio based on the type diameter multiplied by the density multiplied by the velocity divided by the viscosity of the fluid." (AGI Glossary.)

U. S. Government Publications

$$\text{"R} = \text{Reynolds number} = \frac{4Ur}{\nu}$$

"U = mean velocity

"r = hydraulic radius

"ν = kinematic viscosity of water."

(Vanoni, V. A., and Brooks, N. H., 1957, Laboratory studies of the roughness and suspended load of alluvial streams: Final report to Corps of Engineers, U. S. Army, Missouri River Div., p. 117.)

"Reynolds number of the flow

$$\text{"Re}_f = \frac{VD}{\nu}$$

"Re_f = Reynolds number of the flow

"V = Average velocity based on continuity principle

"D = Average depth of flow

"ν = Kinematic viscosity."

(Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. 14.)

REYNOLDS NUMBER (FALLING PARTICLE)

Proposed Definition

Reynolds Number (Falling Particle).--

$$Re_p = \frac{wd}{\nu}$$

Re_p = Reynolds number of the falling particle

w = Fall velocity of sediment particles

d = Median fall diameter of bed material

ν = Kinematic viscosity.

(Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. 11.)

REYNOLDS NUMBER (SHEAR VELOCITY)

Proposed Definition

Reynolds Number (Shear Velocity).--

$$Re_s = \frac{V_* \, d}{\nu} = \frac{11.6 \, d}{\delta'}$$

Re_s = Shear velocity Reynolds number

V_* = Shear velocity which is $\sqrt{gDS} = \sqrt{\tau_o/\rho}$

d = Median fall diameter of bed material

ν = Kinematic viscosity

δ' = Thickness of laminar sublayer

g = Acceleration of gravity

D = Average depth of flow

S = Slope of energy gradient equal to water surface slope in steady uniform flow

τ_o = Tractive or shear force developed on the bed, γDS

ρ = Density of water

γ = Specific weight of water.

(Simons, D. B., Richardson, E. V., and Albertson, M. L., 1961, Flume studies using medium sand (0.45 mm): U.S. Geol. Survey Water-Supply Paper 1498-A, p. 14.)

SOLUTE

Proposed Definition

Solute.--That constituent of a solution which is considered to be dissolved in the other, the solvent. (Hodgman, C. D., ed., 1954, Handbook of chemistry and physics: Cleveland, Ohio, Chem. Rubber Publ. Co., p. 2831.)

Discussion

The solvent is usually present in larger amount than the solute.

Glossaries and Dictionaries

"Solute. A dissolved substance. Ambiguity arises in the case of a liquid dissolved in a liquid, or a gas dissolved in a gas, but the term is seldom used for such solutions. For solids or gases dissolved in water the meaning is unambiguous." (AGI Glossary.)

"Solute. A dissolved substance." (Webster.)

COHESION

Proposed Definition

Cohesion.--The capacity of sticking or adhering together. In effect the cohesion of a soil or rock is that part of its shear strength which does not depend upon interparticle friction. (AGI Glossary.)

Glossaries and Dictionaries

"Cohesion. 1. The resistance of a material, rock or sediment against shear along a surface which is under no pressure." (AGI Glossary.)

"Cohesion. Act or state of cohering; a cleaving together." (Webster.)

AGGREGATE

Proposed Definition

Aggregate.--(Sedimentary Sense) A group of naturally bonded mineral grains which may be separated by mechanical or chemical means.

Glossaries and Dictionaries

"Aggregate. 1. To bring together; to collect or unite into a mass. 2. Composed of a mixture of substances, separable by mechanical means." (AGI Glossary.)

FLOCCULE

Proposed Definition

Floccule.--Small aggregate of particles attracted to each other by electrostatic forces.

FLOCCULATION

Proposed Definition

Flocculation.--The formation of aggregates caused by coalescense of particles that are subjected to certain physicochemical conditions. (Mundorff, J. C., 1961, A program of fluvial sediment investigations in Kansas: State of Kansas Bull., No. 6, p. 46.)

U. S. Government Publications

"Flocculation is formation of aggregates by coalescence of small particles that are subjected to certain physico-chemical conditions." (Jordan, P. R., Jones, B. F., and Petri, L. R., 1964, Chemical quality of surface waters and sedimentation in the Saline River Basin Kansas: U.S. Geol. Survey Water-Supply Paper 1651, p. 83.)

DISPERSION

Proposed Definition

Dispersion.--(Mineral Grains) Deflocculation of aggregates by chemical and mechanical means.

DRAINAGE BASIN

Proposed Definition

Drainage Basin.--A part of the surface of the earth that is occupied by a drainage system, which consists of a surface stream or a body of impounded surface water together with all tributary surface streams and bodies of impounded surface water.

WATERSHED

Proposed Definition

Watershed.--The divide separating one drainage basin from another and in the past has been generally used to convey this meaning. However, over the years, use of the term to signify drainage basin or catchment area has come to predominate, although drainage basin is preferred. Drainage divide, or just divide, is used to denote the boundary between one drainage area and another. Used alone, the term "watershed" is ambiguous and should not be used unless the intended meaning is made clear.

(Langbein, W. B., and Iseri, K. T., 1960, General introduction and hydrologic definitions: U.S. Geol. Survey Water-Supply Paper 1541-A, pages 8 and 21.)

SEDIMENT YIELD

Proposed Definition

Sediment Yield.--The total quantity of sediment contributed from a drainage area. This is equivalent to the sediment discharge from the drainage or the drainage area above a sediment station.

U. S. Government Publications

"Sediment Yield--The total sediment outflow from a watershed or a drainage area at a point of reference and in a specified period of time. This is equal to the sediment discharge from the drainage area." (Inter-Agency Report no. 14, 1963, Methods used in measurement and analysis of sediment loads in streams: Washington, U. S. Govt. Printing Office, p. 13.)

INDEX OF TERMS