SUGGESTIONS TO AUTHORS

OF

THE REPORTS OF THE

UNITED STATES GEOLOGICAL SURVEY

Sixth Edition

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UNITED STATES GEOLOGICAL SURVEY

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By Elna E. Bishop, Edwin B. Eckel, *and* Others

John H. Eric, *Coordinator*

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V. E. McKelvey, *Director*

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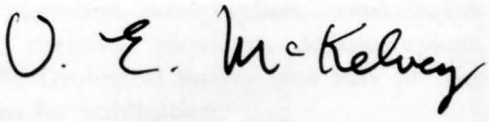
FOREWORD

This sixth edition of "Suggestions to Authors" continues and extends the United States Geological Survey's concern that its reports be clear and understandable. Beginning with its first informal pamphlet on the subject in 1888, the Survey's advice to its authors has emphasized precise and concise use of plain language—"Plain Geology," as Director George Otis Smith put it in the title of his 1915 essay urging writers to express themselves in simple, direct, and clearly understandable terms.

The need for "plain geology" has evolved into the need for "plain earth science" and that need is greater now than ever before: For the sake of our very survival, legislators, policy-making officials, and the general public must come to understand the resource and environmental limitations of the Earth and its processes, and they must be abreast of the results of scientific investigations.

Many scientific communications to this wide audience must be accomplished in two or more stages. First will be the scientific report, which will use scientific terms and phrases to convey precise meanings for which a page or more of description might not be an adequate substitute. Written in "plain earth science," some results may be conveyed in terms useful at once to scientists and the general public. Other results may require translation into simpler, more general terms to reach all those who need the information. More and more, we in the Geological Survey—and other scientists as well—must ask ourselves: Are we communicating our findings in understandable form to those who need them? If the answer is "no," we must be willing to go the extra mile.

Regardless of the audience our varied reports are intended to reach, the information and advice contained in this sixth edition of "Suggestions to Authors" will be helpful to those preparing the reports.



Director

PREFACE

Like the five preceding editions, this sixth edition of "Suggestions to Authors of the Reports of the United States Geological Survey" (STA 6) is written primarily for authors employed by the Survey. For this reason "Survey" appears on many pages. So, too, do references to Survey routines, practices, and philosophy. But though our primary audience is Survey authors, we hope STA 6 will also be used and found helpful by non-Survey earth-science authors, just as earlier editions have been widely used and cited through many years.

We have tried to follow John Ruskin's advice to say what we have to say "in the fewest possible words" and "in the plainest possible words." We have written with the constant awareness of Director V. E. McKelvey's concern that Survey "maps and reports * * * have been released in a form * * * understandable only by other earth scientists. Little wonder that the general public lacks understanding of fundamental resource and environmental problems."

Which is to say that the purpose of scientific communication, written, graphic, or oral, is the same as that of any other kind of communication: to communicate. We hope that followers of STA 6 may communicate with a little more effectiveness and ease and grace than nonfollowers.

We have omitted some of the matter included in earlier editions of STA that, by its nature, quickly became obsolete; we thought these short-lived phenomena were better left to the Survey's technical-standards people. For some subjects we have referred the reader to more comprehensive writings of others. Earth-science research, and the reporting of it, has become too diverse to be covered in detail in a manageable one-volume set of suggestions.

At some places it has been necessary to specify the subdiscipline (s) under discussion and (or) the subdisciplinarian (s) we are addressing, but at many places we use "geologist(s)" in a generic sense to apply to male and female hydrologists, engineers, cartographers, mineralogists, stratigraphers, paleontologists, chemists, physicists, oceanographers, geographers—any member of the Geological Survey who may prepare results of scientific investigations for publication.

We have qualified many of our statements, and the reader will find numerous "in general's." We have tried to base our suggestions on the fact that English is a marvelously rich and flexible language. It has few

absolutes, and there "are an almost infinite number of ways to express almost anything" (U.S. Treasury Department Internal Revenue Service [1962], "Effective Revenue Writing 2," p. 4); we intended to avoid imperative verbs, but a good many seem to have slipped through. We have tried to obey, and urge our readers to do likewise, the command of the late William Strunk, Jr. of Cornell University to "Omit needless words!" and we add our own admonition, "Avoid gobbledygook!"

Zealous readers may discover herewithin inconsistencies of usage and violations of our own precepts. If they do, it won't be necessary to write us. Our story would be that we did it on purpose, to illustrate our basic philosophy that "Suggestions" are suggestions, intended to be applied with common sense and with the knowledge that there are many ways "to express almost anything."

E.E.B.
E.B.E.

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PUBLICATIONS OF THE GEOLOGICAL SURVEY

The Act of Congress which created it in 1879 established the obligation of the U.S. Geological Survey to make public the results of its investigations. These published reports have fallen into two general categories, cartographic and textural, each with supplemental cross-data as needed. The cartographic reports have consisted of topographic, geologic, and hydrologic maps and atlases. The textural reports also have been published in such varied series and formats as were best suited to the material at hand.

For a few years the Survey's cartographic and textual reports appeared only as inclusions to annual reports to the Secretary of the Interior. The first of the separately published book-report series, U.S. Geological Survey Bulletin 1, and the first "Mineral Resources of the United States" (for the calendar year 1882) were published in 1883. Since then, many book reports and maps have been published to record results of investigations of the physical features and resources of the Nation and of parts of the Earth and of the universe.

The individual publications of the Survey through 1970 are listed in two catalogs, "Publications of the Geological Survey," that cover the periods 1879–1961 and 1962–70. Supplementary monthly and annual lists of reports published after 1970 will be periodically combined into other catalogs. The catalogs and supplementary lists, which may be obtained free from many Survey offices, contain directions for ordering available listed items. Many earlier Survey publications are out of print but may be consulted in Survey libraries and in public and institutional libraries.

Survey employees may be issued free copies of any Survey publications that are available and are needed for official use.

In addition to reports published under its own imprint, the Survey releases much of its investigative information through other media. Thousands of Survey-generated reports have been published by cooperating Federal, State, and foreign governmental agencies, and other thousands have been published in scientific and technical journals.

Survey authors should become familiar with the particular Survey series or outside medium toward which their report is pointed for publication. Most publishing organizations have style manuals or technical standards for guidance of their would-be contributors. "Suggestions to Authors" (STA) is concerned mainly with the expositional text that constitutes the Survey's book reports and supplements its atlases and many of its maps. Some non-Survey style guides are listed and annotated at the ends of sections on "The Human Factors" (p. 13) and "Reports Should be Intelligible" (p. 27) and in "Additional Aids for Writers" (p. 28–31).

The Survey's currently (1977) active publications series are listed below.

Book publications

- Professional Papers
- Bulletins
- Water-Supply Papers
- Journal of Research
- Circulars
- Nontechnical publications
- Earthquake Information Bulletins
- Water-Resources Investigations
- Water-Resources Data Reports
- Techniques of Water-Resources Investigations
- Reports available through National Technical Information Service
- United States Geological Survey Annual Report
- Open-file reports

Maps

- Geologic Quadrangle Maps
- Geophysical Investigations Maps
- Miscellaneous Investigations Series
- Antarctica Reconnaissance Series
- Geologic Atlas of the Moon
- Coal Investigations Maps
- Oil and Gas Investigations Maps and Charts
- Miscellaneous Field Studies Maps
- Mineral Investigations Resource Maps
- Special geologic maps (includes State and National geologic maps)

Hydrologic Investigations Atlases
State water-resources investigations folders
State hydrologic unit maps
National Topographic Maps
Standard series maps
1:24 000-scale, 7½-minute
1:62 500-scale, 15-minute
1:100 000-scale
1:250 000-scale
1:1 000 000-scale International Map of the World
Special maps
National parks and monuments
Orthophotomaps
Orthophotoquads
County maps
State maps
National Atlas products
Maps of the United States

CHOICE OF PUBLICATION FORMAT

Selection of the appropriate publication format or medium requires consideration of size and character of primary audience, of degree of permanence of the information, of size and character of illustrations, of immediacy, economics, precedent, and, perhaps of least importance, personal preferences of the author and his supervisor. Except for reports destined for scientific journals, the subject matter and size of the manuscript have less to do with the choice of publication medium than do some of the other factors listed. If a report is needed quickly by a small audience and is likely to be of ephemeral interest, it may be released in the Survey's open files or published as a Circular, rather than in one of the more formal series. As it is with book reports so it is with maps. The Geologic Quadrangle (GQ) map series has rigid restrictions as to base, scale, and size, is in color, and represents a high development of the cartographer's art. A map that is as accurate and permanent as a GQ map but that shows an area different from that of a standard quadrangle usually will appear in one of the other map series. So, too, will one that does not require color or that emphasizes only certain features, such as geochemical anomalies or hydrologic characteristics of the terrain.

Many of the factors listed above apply also to non-Survey publications. The author can determine a journal's preference as to subject matter, article size, and illustrations policy by examining recent examples of the series and by studying the journal's own statements as to policy, specifications, and hints on style. Such statements are printed periodically as front or back matter in many journals, and they can be obtained by writing to the publishers.

Most final decisions as to publication media for specific reports are made by authorities higher than the author, but he should seek advice and tentative decisions as to his probable outlet early in the manuscript-preparation process; only then can he efficiently plan and prepare the illustrations, text, and tables.

THE SURVEY PUBLICATIONS PROCESS

The Survey publications process may be defined as the transformation of raw field, laboratory, and other research data into finished scientific reports. In general, a "Survey publication," as the term is used in this book, is a textual or cartographic report that is made available for public inspection on authority of the Director of the Survey.

When the author has submitted his finished (he thinks) manuscript to his supervisor, only the first lap of the long obstacle-filled and time-consuming process of transforming raw data into finished publication has been completed.

The report will first be reviewed for scientific validity by specialists within the originating branch and within other branches and Divisions for examination of parts related to those units' fields. The reviewers will point out any weak or doubtful spots in text and illustrations by means of marginal notes or interlineations, or (if their questions, criticisms, and suggestions are numerous or involved) by attached memorandums.

The author should give every comment thoughtful consideration. Where suggestions are acceptable he should make the appropriate changes or corrections. Where he differs with the reviewer he should indicate on the manuscript or on the margin of the attached memorandum why he differs and whether he has made any changes. If the differences of opinion are substantial or if there seem to be misunderstandings, the author may explain his views in written comments and attach them to the manuscript. Where possible, informal consultation and discussion between the reviewers and the author are highly desirable to clarify viewpoints and reach agreement.

If the report is to be open filed or is to be made available only through the National Technical Information Service, the author's labors are done once the Director has approved release; his Division's publications unit will arrange for deposition of the material and for announcement of its availability in the monthly "New Publications of the Geological Survey." Reports to be released in the more formal Professional Paper, Bulletin, Water-Supply Paper, Circular, and various map and atlas series will be sent to the Survey's Publications Division for accomplishment of publication.

In the Publications Division, the "mill" copies and the author's originals of the illustrations will be sent to the cartographic unit for preparation for printing. The manuscript will go to the editing unit for review of compliance with Survey publications style and to be marked for typsetting. After this segment of the Publications Division's processing is completed, the edited manuscript will be sent to the author for final review before typesetting.

In transmitting the edited copy for review, the Publications Division urges authors that "NOW is the time to correct existing errors. Corrections that are made later at proof stage are time consuming and expensive. In proof, changes in text will be limited almost entirely to errors of typography or fact, and changes in art will be limited to major errors of fact." And the sooner the author approves and returns the edited material to the Publications Division, the sooner the next step in the publications process, that is, the actual setting in type, can be completed.

After typesetting, the author is furnished proof of the text and illustrations, together with the original manuscript material. For suggestions on proofreading, see pages 112–115. The author-corrected proof is returned through channels to the printer, who corrects his typesetting and prints the report.

When the report has been printed and bound and is ready for distribution, the author will be furnished a limited number of copies of his book, map, or Survey research-journal article.

The Survey publications process may seem slow and ponderous, and indeed it is. The Publications Division and the operating Divisions strive constantly, but not always successfully, to reduce the time elapsed between initial submission of manuscript and release of printed report. Many factors enter this time problem, such as changes in priorities, new programs and projects, reorganizations, reassignments of responsible individuals, failures to set and enforce attainable deadlines, changes in appropriations or allotments, acceptances of resignations or retirements without cleanup of report obligations. Authors themselves often are a significant part of the reason for delayed publication. Changing intellectual interests, with consequent tendency to drop the old in favor of new pursuits, may affect progress on a report. Whatever the reason, a glance at almost any manuscript routing sheet will show that the manuscript has spent more time with the author—between technical reviews and revisions, between editing and author-approval, and between receipt of proof and completion of author proofreading—than it has in any other unit in the publications process.

The steps of the Survey publications process outlined above apply to the routine report. If a report has some special urgency, it may be given

the "rush" treatment, in the course of which some of the steps may be telescoped or otherwise varied. But the end product will be of higher quality if the author and his supervisor so plan his work that his report can be printed in the established publications process.

THE HUMAN FACTORS

We have described the mechanics of the Survey publications process, but the process is not entirely mechanical. There are points at which human factors enter strongly, where ego meets ego. Ideally these meetings should be harmonious and mutually profitable, but the publications world is of course no more ideal than any other world, and here, as elsewhere when egos meet, bruises may occur.

The points in the Survey publications process where the most bruises occur are where author meets reviewer and where author meets editor. The meetings of no two of these egos can be the same, so no firm easement procedures can be established. Our suggestion is that all concerned should at all times and in all circumstances exhibit courtesy, goodwill, and mutual professional respect. Reviewers and editors should make their suggestions tactfully. The author should receive suggestions with an open mind, and he should remember that he is only one member of the publications group and that other members of the group also have responsibilities to the Survey and to the readers of Survey reports. The author should keep in mind, too, that he is not the owner of his report. The Survey pays his salary, furnishes him office, laboratory, library, and other facilities—and owns the results of his research.

However, such limited restrictions as the Survey publications process may impose on the author's "freedom of speech" are only for the purpose of insuring scientific validity and intelligibility, within the limits of accepted literary usage, to the audience for which the paper is written. The warm welcomes that most Survey-generated and -reviewed reports receive when submitted to non-Survey scientific publishing organizations for publication testify to the value of "the system."

Author and Technical Reviewer

Aside from the writing of the manuscript, the technical (critical) review is possibly the most important step in the transformation of research results into a published report. The author is too close to his work; a fresh objective look by someone else is essential in order to spot errors in fact or reasoning, inconsistencies, or poor organization and presentation that may obscure what the author has tried to say. Even though it represents the best reasoning, exposition, and organization of

which the author is capable, every manuscript will benefit from conscientious technical review, preferably by two people—one who is thoroughly familiar with the subject matter and one who is not but who can more nearly represent the average reader.

In assigning reviewers, the supervisor should choose them carefully and should stress the importance of their jobs. They should know that, though the supervisor will rely heavily on their judgments, he will also be reviewing the quality of the reviews in the course of supervisory approval of the manuscripts. Inadequate reviews lead to problems and delays in the publications process and to publications that are disappointing to author, publisher, and reader alike. Technical review is mandatory within the Survey and in most other research organizations.

The critical technical review of the whole paper is distinct from, and commonly precedes, such specialized reviews as those for geologic maps, usage of stratigraphic and geographic names, and the like.

Most of the rest of this section is taken without much change from Cochran, Fenner, and Hill (1974) and from "Suggestions to Critics," a paper for internal Survey use which is on file in Survey libraries. "Suggestions to Critics" was written in 1949, but it contains advice to reviewers and authors which is as pertinent now as when it was written.

The main attention of the critical reviewers will be focused on the scientific content: Has the author drawn conclusions from insufficient evidence? Has he overlooked alternative hypotheses? Are the facts well documented and correct as stated? Does the paper contain digressions or discussion of controversial hypotheses that might better be excised and published elsewhere? In view of the probable audience for this particular paper, is the emphasis acceptable? Do the facts shown on the illustrations coincide with the descriptions and interpretations of them as given in the text? Are the illustrations legible, complete, and in correct form for the publication intended?

The critic will also watch for errors of omission and commission that would reflect on the author or his employer, such as: permission to use, and proper acknowledgment of, borrowed data or ideas (especially "company confidential" material); credit to collaborators; and adequacy of references cited in terms of professional ethics. The author will receive most of the praise or blame for his report, but in this he is not separable from his employer, and anything that reflects on the one also reflects on the other.

Each critic has his own methods for review of a manuscript. Nearly all experienced ones find, however, that they do their best and most helpful reviews by avoiding interruptions and staying with a manuscript until the review is completed. The thoughtful technical review is too important to the author, to the smooth forward progress of the re-

port, and to the ultimate reader to justify anything but the reviewer's undivided attention.

First, the entire paper should be inspected quickly to obtain an idea of the general form of the report, of its weak points, and of its message for the audience to whom it is addressed. On a second and more careful reading of both text and illustrations, all the items that raise questions or that need further attention should be noted. Some critics mark transpositions or write comments directly on the manuscript, but many prefer to identify questionable passages with key numbers and to build up a running list of queries, comments, and, if necessary, suggested rewrites. Illustrations should be marked lightly, if at all, and leaders should be used between map features to notes on the margin.

Another reading of manuscript and of tentative comments should result in a final list of clearly expressed suggestions, amended as necessary from the original ones. This step should be followed by an overall review of the manuscript. Its good points (which all manuscripts have) should be emphasized, but the bad and questionable qualities must also be stated forthrightly. Sarcasm and wisecracks should be avoided.

If the paper requires further review by others, as for a subject on which the critic feels incompetent, the review should so state. The review should tell the author and his supervisor, in general terms, what they need to know about the quality of the manuscript and what needs to be done to make it even better.

The critic will probably find it difficult to separate his review of the technical content of the manuscript from its presentation. Words, phrases, and paragraphs are tools for reporting to others the facts and inferences that are in the author's mind, and if the tools are dull or ill-chosen, the report will not be understood correctly by the reader; if the facts and inferences are poorly understood, no skills in presentation can hide their weaknesses.

However, adequate criticism of a manuscript is inevitably a two-sided problem: (a) examining the soundness of the data, reasoning and conclusions (technical reviewing), and (b) helping the author to transmit his ideas into the mind of the reader with a minimum of distortion (editing). The critic must use his own best judgment in treading the narrow path between technical review and editing. He should feel free to suggest any changes in organization, expression, or other facets of the presentation that might make the report more understandable and useful to the reader, but both he and the author should stand ready to defer to the editor's later suggestions on these matters.

The critic should rewrite no more than is necessary to test his interpretation of a statement in his own mind; few authors learn much from being spoon fed, even when the critic's revision results in marked improvement. If the entire paper, or significant parts of it, requires

rewriting, the critic should say so. Given specific advice as to his paper's deficiencies, the author should be able to do a better job of revision than can anyone else, and he will learn from the experience.

Authors seldom believe it until they become technical critics themselves, but the fact is that nearly all critics are people of good will, genuinely trying to help the author. Criticism is at best a thankless job, done by people who would much rather pursue original research than review manuscripts by others. Rarely, the critic may run across a gem of new thought in his own specialty; if he does, he will be grateful for the critical assignment. More often, his job will be a sterile one for him personally, done in the knowledge that his help is as likely as not to upset or antagonize the one he is trying to help.

The author, then, should approach the critics's comments on his manuscript with an open, cool mind. He must realize every comment deserves his thorough and objective consideration. Some critical comments may seem at first to be so wrong as to imply gross carelessness, if not downright stupidity, on the part of the critic. Such implications are almost certainly wrong. The author must assume that the more "stupid" a critic's comments, the more the original manuscript deserves careful restudy. Surely something in the expression, the facts presented, or the reasoning led the critic astray and caused him to make the "stupid" comment or mark. The critic has read the manuscript more carefully and with more background knowledge than will the ultimate reader; if he missed the author's point, so too will the reader of the published report.

Most differences between author and critic can be resolved by frank discussion face to face, if possible, but in writing if not. Should differences persist, it may be necessary to go to higher authority, to ask for a new review by a disinterested party, or to arrange for a joint study of the original field or laboratory evidence.

Papers by Survey authors that are submitted to outside journals for publication are commonly given an additional round of technical review by the outside organization. The journal editor usually receives many more manuscripts than he can publish, and he must choose those papers that best fit the needs of his particular audience and that fit within the policies and restrictions of his organization. To help him in his decisions, the editor may seek the advice of one or more critics who are specialists in the subject matter of a particular manuscript. The author will be well advised to accede gracefully to the journal editor's policies. If his research and conclusions are sound, they will stand up to additional technical review. And if his paper is accepted, it will probably be published promptly and will be seen by the audience most interested in it.

Author and Editor

Any publishing unit that has more than one author, one editor, and one typist must have a generally agreed-upon publications style. Many aspects of the style will be neither "right" nor "wrong"; they will just be "our style" or the "way we do it" in that unit.

Survey publications style is governed by the "U.S. Government Printing Office Style Manual," "Suggestions to Authors of the Reports of the United States Geological Survey," and such guides and technical standards as are issued by Survey administrative and operating units. STA consists, as its title says, of suggestions, as critical reviewers and editors will be aware. But the author, in turn, must be aware that reviewers and editors stand temporarily in place of the reader, and if, unlike the customer, the reader is not always right, he is still the final authority on the value of the publication. Too, the editor is the last inspector, the last possibility of saving the author and the Survey from publishing an embarrassing, overlooked error.

But editors seem to gall authors even more intensively and extensively than do critical reviewers. The editor, by existing, apparently violates the author's sense of territory. In a discussion of authorial psychology, Tichy (1966, p. 309) notes that an author's "feelings about his writing are more sensitive and tender than his feelings about his performance in his science or technology. * * * An engineer will defend at length a dangling modifier or a pronoun without antecedent [as though he had been accused of having a 'personality defect'], but he will correct an error in engineering the moment it is pointed out to him." Tichy speculates that unrelated family matters, financial worries, and even marital problems may affect an author's attitude toward the editing of his work. And the editor never ceases to be dumfounded at the intensity of the author's objection to what the editor thinks of as a minor, needed correction.

The editor, then, must remember that editing is not an exact science and that it's the author's name that is going on the title page, the backstrip, and the library card. The editor himself is going to a nameless grave; his suggestions therefore should be tentative, tactful, and needed, and marked in inconspicuous pencil—never, never in red pencil or in ink.

On the other hand, skill in scientific research is not synonymous with skill in communicating the results of that research, and writing skills are acquired in the same way as other artistic skills—by long, conscientious practice. So the author might remember in humility that one dissertation does not make a writer and in charity that the editor may also have put some pride and heart's blood into his work. Author

and editor both should avoid "I" and "you" in dealing with each other; strictly impersonal courtesy should be maintained, no matter how tightly the teeth may be clinched. Thus some of the more stereotyped author-editor disagreements may be avoided:

1. "You changed my meaning!" No cliche is quite so timeworn to an editor as the pained cry of a not-too-lucid author, "You changed my meaning! Stet!!" Of all things an editor never intends to do, to change an author's meaning surely heads the list. If the meaning is ambiguous or otherwise not clear, it is part of the editor's job to try to clarify it. And if the editor guesses wrong as to the intended meaning, the author should bear in mind that the editor, poor soul, has probably read as many technical earth-science papers as any potential reader, that the reader is unlikely to be any more gifted with intuition than was the editor, and that therefore a rewording is in order, by the author if the editor's is not acceptable.

2. "A geologist [or a hydrologist, or a paleontologist] would understand." That's as may be; but even if a geologist, or a hydrologist, or a paleontologist would understand, the Survey likes its reports to have correct grammar, clear syntax, and logical organization; consistent use of technical terminology; pertinence and correct identification of tables, illustrations, and bibliographic references; coincidence of geographic locations as given in the text and as shown on the maps; correct arithmetic totals of measured stratigraphic columns; and undangled participles. So forbearance must be accorded the editor.

3. "Nitpicking." True, true. Editing consists of a myriad of trivia, or nits, very few important enough in themselves to be argued over, but editing is a critical phase of the whole process that, let us hope, in the end produces a tight, logical, cohesive, well-organized, unambiguous, well-indexed Survey report.

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Cochran, Wendell, Fenner, Peter, and Hill, Mary, eds., 1974, Geowriting (2d ed.): Falls Church, Va., American Geological Institute, 80 p.
A brief, well-written guide to writing, editing, and printing of earth-science reports, by some who have been there.

Tichy, H. J., 1966, Effective writing for engineers, managers, scientists: New York, John Wiley, 337 p.
An editor with many years of experience in dealing with sensitive authorial egos writes with sympathetic insight on the successful care and feeding of them.

U.S. Geological Survey, 1958, Suggestions to authors of the reports of the United States Geological Survey (5th ed.) [STA 5]: 255 p. *See* Wood, 1909, for earlier editions.

U.S. Government Printing Office, 1973, Style manual: Washington, 548 p.

The GPO style manual is the official guidebook for Federal editors and copy preparers in matters of capitalization, spelling, compounding, punctuation, tabulation, abbreviation, and signs and symbols. Some agencies are permitted certain variations, but Survey publications in general follow the manual closely.

Wood, G. M., Suggestions to authors * * *, 1909, [STA 1] 50 p.; 1913 (2d ed.), [STA 2] 60 p.; 1916 (3d ed.), [STA 3] 120 p.; revised by B. H. Lane, 1935 (4th ed.), [STA 4] 126 p.: U.S. Geological Survey.

OBSTRUCTIONS IN THE WRITERS PATH

Many obstructions lie in the path of the technical writer. Recognition of some of them, and of their causes and treatment, may make the path easier for the young writer, though it is seldom smooth even for experienced writers. Most of these obstructions, or roadblocks, or bugaboos, are at least partly psychological, and they are presented here with apologies to the professional psychologists.

Every writer can write more easily under some physical and psychological conditions than under others. It is important to recognize these personal idiosyncracies and to humor them as far as possible. Some physical conditions, such as office space, lighting, and room temperatures, may be beyond the writer's control. Some personal preferences, too, are obviously unattainable or so wrong that they should be avoided or changed. On the whole, however, anything that makes the writer more comfortable will also make his thoughts flow more easily from his mind to his paper.

One writer may prefer to use pencil and may even feel most comfortable with pencils of a certain hardness; another may write most easily with a pen—on yellow paper. Still another may find that his thoughts flow best directly into a typewriter, or he may prefer to prepare even his first draft by dictation to a machine or to a stenographer. Some writers find that they can revise and improve a manuscript only after it is typed; for other writers a manuscript typed is a manuscript sacredly immutable, whereas they can make changes in a penciled version without compunction.

Some writers do their best thinking, and writing, on a couch or with their feet on the desk, or perched on a drafting stool. Others are more comfortable, and more productive, seated in a certain kind of chair.

One writer may prefer to accumulate his entire manuscript in rough form before sending it to the typist; others prefer to have segments typed as they are produced and to revise and polish these segments at odd moments while other segments are being drafted.

Some people are at their best in the morning, others late in the day or even at night. But few people can produce good manuscripts for 8 hours at a time, so the writer should reserve his "best" hours for writing.

Reading, study, field notes, conferences, and the like can fill the other hours.

This listing of special preferences could be extended indefinitely, for every individual has his own. To repeat: Every writer should identify his own idiosyncracies and humor them to the extent possible.

At the outset of a writing assignment nearly every writer goes through a gestation period. Its duration commonly varies more or less directly with the size of the job ahead; it may last from a few minutes for a brief technical or administrative memorandum to several weeks or longer for a major report. This period is one of mental and physical anguish. The would-be writer welcomes interruptions and is seldom averse to interrupting the work of others. He may have strong guilt feelings that he is accomplishing nothing and is loafing on the job—and may give his colleagues the same impression. His visible productivity is almost nil.

This gestation period is a necessary preliminary to writing good reports; the mind is busy with facts, plans, dreams, and ideas. Initially these are formless, disordered, and confused, but by a combination of conscious and subconscious processes they gradually assume substance, form, and order. When these processes approach completion, the writer is ready to begin giving birth to his report.

The gestation discomfort may be alleviated to some extent: First, it should be recognized as a normal and natural process, common to all writers; thus, patience with himself (and possibly also patience on the part of an understanding supervisor) is needed. Second, the writer must convince himself that he really has something to write—that he has done the essential work and thinking in field, laboratory, and library and has information that should be given to others. Third, the writer must begin to write. Starting anywhere in the report, on the most appealing segment or not, he must put words and thoughts on paper. The first few pages may be disordered and meaningless scribbling, but soon the mind clears, and meaningful and usable sentences or even whole pages appear. At that point the gestation period is over, and the report is launched.

Even after his report is well underway and many thoughts have been transferred to paper, the writer may find that his mind has gone blank and his forward progress has ceased. This mental block, similar in many respects to the gestation period, commonly occurs at the beginning of work on a new segment of the report.

Mental blocks may simply reflect temporary fatigue from the physical aspects of writing. More often, reflection will show the writer either that he is ignorant of some of the needed facts or else that he has so many facts that they fail to mesh into a coherent whole.

Several possible remedies are available for mental blocks. One is to identify the problem, to face it squarely, and to think it out, with or without conversation or advice from colleagues. A more likely solution is a postponement of work on the blocked section. As is true of the gestation period, postponement will allow time for the subconscious to take over or for accumulation of new facts if they are needed. When the writer then returns to the problem section, the block probably will have disappeared.

Even the best of writers may turn out a report containing a segment wherein the writing seems confused. The writer himself may discover this defective segment while rereading finished parts of his manuscript. More often, it is a technical reviewer or editor who first sees evidence of confusion.

Such a confused passage in the midst of an otherwise well-written manuscript is a sure sign of confused thinking and usually represents either a subconscious coverup of ignorance of the particular subject matter or of inadequate reasoning applied to it. One remedy for a passage of confused writing is to learn enough about the subject to permit clear thinking, hence a clearer revision. Another possible remedy, and one that should be thoroughly considered, is to drop the faulty segment completely or to plan to publish it in a separate paper. Not everything on a given subject that is in a writer's head or notebook need appear in a single comprehensive report. The segment that is most difficult to write may concern data that have received inadequate thought precisely because they had little bearing on the main subject.

A final obstacle that may make a writer's path anything but smooth may be termed the "finish-line letdown." This problem affects nearly all writers. It occurs toward the end of the writing process, just as loose ends are being caught up and the final manuscript is being readied for review by supervisors and technical critics. Suddenly the writer becomes obsessed with feelings that his work is wasted and meaningless. It seems to him that either his subject is of little or no scientific importance or that he has adduced no facts or theories that are not already widely known to fellow scientists.

The remedy for the problem is to realize that it represents a normal psychological letdown that is common to all but the brashest and most self-centered of writers. Once this realization is reached, it should be easy to realize further that the original research work would not have been supported had it been worthless and that, for the time being at least, the writer probably knows more than anyone else about his subject. The obvious corollary is that it is the writer's duty, and should be his pleasure, to pass his knowledge on to others.

OF OBLIGATIONS, DUTIES, ETHICS, AND GOOD PRACTICES

From raw data to finished report, the author is only the first among equals who contribute to the end product. Critical reviewers, editors, illustrators, cartographers, printers, and distributors play essential roles in the publications process. The fifth edition of "Suggestions to Authors" reminds authors sternly on page 1 "that the Survey has a proprietary interest in all their manuscript reports and as proprietor may dispose of the reports or require that they be changed before publication, as it sees fit." Actually this "proprietary interest" has always been exercised with the gentlest of restraints and "only to the extent of seeing that a report is scientifically and technically sound, will reach the proper audience, and will reflect credit on both the Survey and the author." But if a Survey report is not a one-man show, the author remains the star of the cast.

This author-star of the large team that is involved in adding his report to the literature of earth sciences owes to the team, to himself, and above all to the Survey the highest of ethical standards and professional practices, a few reminders of which are summarized here.

1. Learn to write

As a tax-supported institution, the Survey is obligated to make the results of its research available to the public. It must therefore require publishable reports from its research staff, and a primary duty of the young research-staff member is to learn to write as well as he possibly can. To a large extent it will be up to him to be his own teacher, perhaps on his own time. The only way to learn to write well is by copious practice, and scientific research in and of itself seldom involves much practice in writing. A second-year journalism student, taking advanced reporting, feature-story writing, advertising-copy writing, and perhaps short-story writing on the side, might produce more "plain" prose, omitting "needless words," in one term than a topflight research scientist would have occasion to in a lifetime. So let us emphasize and reemphasize: The only way to learn to write is to practice writing.

The Survey scientist who takes the trouble to train himself to write well will likely find that what is good for the Survey is also good for its scientists. A few scientists manage to achieve stature in their profession by means of the spoken word, but a surer way to recognition is by producing high-quality publications in whatever quantity the scientist can manage. This tendency in the scientific (and academic) world to equate fitness for advancement with number of published reports may be right or wrong, but it is a reality—perhaps because published reports are easily measured evidence of a scientist's productivity. Even the rare scientist who is immune to the normal needs or desires for promotion and financial advancement will find that professional recognition such as election to fellowship or high office in scientific societies is based more on his published writings than on anything else he has accomplished.

The Survey scientist is not likely to become a "great writer," if for no other reason than that he probably won't get enough practice, but he must not believe that "geologist" and "good writer" are a contradiction in terms, nor should he convince himself that writers are born, not made, and that he wasn't born a writer. Few writers are "born"; even great writers become writers the same way Paderewski became a great pianist; by practicing, and practicing, and practicing, and practicing some more; by writing, and writing, and writing, or perhaps by writing and rewriting, writing and rewriting, writing and rewriting. An eminent jurist believed there is no such thing as "good writing"; there is only good rewriting, he believed.

The only way to learn to write is to practice writing, but broad reading enriches the vocabulary as well as the mind, and occasional analytical reading may be helpful: Take a passage that seems unusually effective and try, word by word, to determine how the writer achieved such effectiveness. Or take a passage that seems unusually ineffective and try, word by word, to determine how the writer achieved such ineffectiveness. How would you have written it? Rewrite the passage a few times and compare with the original.

There are many grammars, technical manuals, style guides, glossaries, word-usage guides, dictionaries, handbooks, and other aids for the needy author. Most of these references can be helpful within the limits of their particular scope. Authors should become familiar with a wide-enough range of aids to cover their needs.

Attendance at writing classes and conferences, particularly those that include one-to-one criticism, is profitable to some would-be authors. The weakness of many such efforts is that the really qualified critic may not be able to bring himself to point out in cold blood just how

poor the student's writing is, and the student's ego might not survive such brutality if the critic could inflict it.

To repeat: The only way to learn to write is to practice writing. Writing and learning to write are lonely, one-man, often depressing and discouraging jobs, but the Survey scientist owes it to the Survey and to himself to learn to write as well as he can.

2. Be accurate

Probably it should have been listed first, but the subject is delicate, and we tend to put off the discomfiting. However, long experience in the publishing field has shown us the need to point out that, concomitant with the scientist's obligation to write, is the obligation to write accurately. Accuracy of data is an obligation, a duty, an ethic, a good practice, and a necessity—accuracy not only of geologic, paleontologic, and other scientific data, but of simple arithmetic and geographic data. If the text mentions a site "northeast of the town of Boondocks," the location of the site on the map should not be shown as due south of Boondocks. The total of bed thicknesses shown on the bottom line of a stratigraphic column should be the total of individual bed thicknesses as machine-proved, and if the total is a rounded one that fact should be stated. It will inspire confidence and save time for reviewers and editors if machine tapes of computations accompany the manuscript.

3. Finish your work promptly

The author is obligated to complete his manuscript report, the objective of each investigation, as soon as possible after the close of the investigation. If he resigns from the Survey, he is obligated to complete and turn in his report before the effective date of his resignation. Furthermore, even though he completes his report before he leaves the Survey and thus satisfies that obligation, he may endanger his reputation and may embarrass the Survey if, in working for a private employer in the area that he knows from his Government employment, he uses unpublished information obtained during that employment. His integrity and honor as a scientist are relied upon by the Geological Survey to insure his conformance at all times to ethical personal and professional conduct in the use of information obtained through Survey investigations.

The responsibility for the prompt completion of a report is shared by the author's supervisor, who should plan clearly and concretely with the author the one or more reports that will present the results

of the investigation. This planning should be done before fieldwork or laboratory study is begun and should be adhered to as closely as possible. Such planning gives the author an understanding of his goal and his duties at all stages of his study from the beginning until the manuscript is completed. If the author is fortunate, his supervisor will not find it necessary to assign him to new duties until his project or manuscript-in-progress is complete.

When the manuscript is complete, the responsibility of getting it through the review, editing, and publication stages falls on the author's supervisor and other supervisors. They should keep the manuscript moving by avoiding unnecessary delays in the various processing channels.

4. Acknowledge explicitly all cooperation, sources, and borrowed data

The nature of cooperative relationships should be stated explicitly in the introductory, or another, section of the Survey's reports. If the investigation has involved formal cooperation, a concise statement of the cooperation must also be put on the cover and on the title page of book reports and on separately published maps, charts, and atlases. In reporting on the geology or water resources of areas outside the United States, special care should be taken to avoid hurting the pride or sensitivities of coworkers and of the host country. This caution ranges from small matters such as correct use of personal titles to the larger things such as criticism of local customs and facilities. Remember, too, that mapping standards, both as to accuracy and as to appearance, differ from one country to another.

Many factual comparisons are made in reports, but these should be worded so that they do not cause offense or wrong impressions. An author who in describing the results of his investigation must relate his work to that of contemporaries or earlier workers will do well to concentrate on a clear, logical presentation of his own subject; statements about other writers and quotations from other writings should be so skillfully incorporated that they contribute to, and do not distract the reader from, the author's presentation of his subject. The author's expressed opinions, especially about writers who have published mistakes or who hold contrary views, should always be presented in a tactful and dignified manner. The young scientist who finds a mistake in his predecessor's work, particularly if the predecessor is one of the greats of the profession, may tingle with self-satisfaction, but before he gloats in print he should consider the state of knowledge and the working conditions that prevailed when the mistake was made. He may even

discover that the mistaken one was not great at all at the time but rather a youngster on the way up.

The author should obtain permission to use, and should give proper acknowledgment of, borrowed data or conclusions. He should give appropriate credit for data or conclusions contributed by collaborators. He must obtain permission of mining or other companies to publish information obtained in confidence, such as mine maps and production data; this permission should be indicated in the manuscript or in attached documents.

Company names and trade names of equipment or material should generally be avoided in Survey reports unless there are special reasons for their inclusion. This principle applies to photographs showing either the names of companies or trade names on equipment or material.

5. Identify authority for cited non-Survey data

Discussions of subjects outside the primary fields of activity or competence of the Geological Survey require citation of authorities. For example, statements giving the limits of chemical constituents acceptable for public water supply should cite appropriate State standards and (or) those of the Environmental Protection Agency; statements concerning limits of such constituents in water used for irrigation should also cite an authoritative source.

6. Much may be in a name

An author should decide early in his writing career the form in which he wants his name to appear on his reports; confusion will be avoided if the form is not changed. Use of his first name and middle initial is preferable. Where name similarities occur, a distinctive combination of names or initials should be used. Except where similarities are involved, Survey bibliographic citations commonly give only the initials unless there is only one given name; a single given name is spelled out. (See also discussion of name forms on p. 76).

Women scientists, who may change their names by marriage, should consider the desirability of retaining one name for professional purposes throughout their careers. A change to a husband's surname not only brings grief to bibliographers and librarians, but may dilute the effect of the scientist's life work on the science and on her own stature in the profession.

Reference

U.S. Geological Survey, 1958, Suggestions to authors of the reports of the United States Geological Survey (5th ed.) : 255 p.

REPORTS SHOULD BE INTELLIGIBLE

Scientific thought is exact and direct, and scientific writing must therefore be accurate and to the point. * * * [Any] writer's first duty is to be intelligible. * * * [Plain] writing is not something beneath the plane of endeavor of the scientific investigator * * *. It is our ambition that the reports of the Geological Survey shall be written in the language of the people.

—George Otis Smith (1915, p. 630–632)

In 1973, Survey Director V. E. McKelvey said:

[Policies, plans, and decisions concerning] resource adequacy, strip-mining, land use * * *, powerplant siting, preservation of coastal wetlands, wilderness area withdrawals, offshore drilling, * * * surface and subsurface waste disposal, air pollution and [other problems] that are central issues in the United States today are * * * made by legislators, social scientists, lawyers, and others who understand and represent people, but who do not understand [scientific] language. [The information required to solve these problems needs] to be in plain terms and in forms in which it can be used effectively * * *.

In our efforts to increase the use of resource and land information in planning and decision-making, we have found that one of the most difficult problems is how to bridge the information gap between scientists and nonscientists * * *. The earth scientists, on the one hand, and the planning and urban decision-making community on the other, despite the best efforts of both, have been unable to totally bridge the gap between them.

Every edition of "Suggestions to Authors" has stressed the need for intelligibility. "The author should express his meaning concisely and avoid unnecessary repetition," wrote George McLane Wood in STA 1 (1909, p. 7). The compilers of the fifth edition (1958) put the same idea on page 1: "To insure effectiveness, reports must be not only accurate but so clearly and simply written that they are easy to read and understand." We might revise this advice to add the phrase "by the audience to which they are directed." The effective speaker or writer must have clearly in mind the message he has to give and the audience to which his message is directed. Reports of Survey research in the more esoteric aspects of earth sciences that have developed in the last few decades perhaps cannot be "written in the language of the people." Consequently, in this sixth edition of "Suggestions to Authors," detailed suggestions for these highly specialized reports are left to the appropriate operating units. The suggestions herein are pointed toward general applicability, for no matter how esoteric the message, the purpose of writing today is the same as it was when hieroglyphics were scratched on clay tablets: to tell somebody something, to report data accurately,

to present information intelligibly for contemporary and future readers. And employees of tax-supported organizations may be reminded that it's no disgrace to be intelligible to the taxpayer.

"Omit Needless Words!"

—Strunk and White (1972, p. IX, 17)

Certainly it is excellent discipline for an author to feel that he must say all that he has to say in the fewest possible words, or his reader will be sure to skip them; and in the plainest possible words, or his reader will certainly misunderstand them. Generally, also, a downright fact may be told in a plain way; and we want downright facts at present more than anything else.

—John Ruskin, as quoted in first edition of "Suggestions to Authors" (Wood, 1909, p. 37)

In general, the shorter and more concise a scientific report, the better. A lean, concise report will be published faster and more cheaply than a long, rambling one, and it will be read and understood by more readers than would a longer one that has the same message.

An adequate brief manuscript will almost certainly require more of an author's time, energy, and skill than will production of a fat-filled mass of prose and statistics. The old joke that runs "Please forgive this long letter; had I more time it would be shorter" carries a lesson for all of us.

The art and skill of writing concisely demands abundant patience and some basic knowledge of writing. Because the abstract represents the ultimate desirable condensation of most reports, perhaps abstract preparation is as good a place as any to learn the art. The well-written abstract tells in as few words as possible all the essential facts or inferences that are presented more elaborately in the report itself. Writing several abstracts of the same manuscript, each one shorter than the last, is excellent practice for an author in learning to say "all he has to say in the fewest possible words." The necessity of writing an abstract in a set number of words also inhibits verbosity. Given rigid limitations, verbiage can be slashed without loss of message.

After the author has completed his manuscript, he should, if possible, let it cool for a while. Then, before he sends it to technical review, he will do well to go over it to dispense with unnecessary words, phrases, sentences, and paragraphs. Tichy (1966, p. 8–15) advises writers that there are four steps to authorship: planning, writing, cooling, and revising; she gives suggestions for the first, second, third, fourth, and fifth revisions!

Significant shortening ("condensation,") may be demanded by a space-conscious supervisor or journal editor, or one of them may under-

take the shortening. If the author himself condenses before he sends the manuscript forward, the process will probably be less painful and also more conducive to speedy publication.

"Avoid Gobbledygook!"

—Bishop, Eckel, and others, (1977, p. 25)

William Strunk, Jr. of Cornell University commanded his students to "Omit needless words! Omit needless words! Omit needless words!" (Strunk and White, 1959, p. 17). Strunk taught before the word "gobbledygook" was coined, else he must certainly have also commanded "Avoid gobbledygook! Avoid gobbledygook! Avoid gobbledygook!"

"Webster's Third New International Dictionary of the English Language" (WNI 3) defines "gobbledygook" as "inflated, involved, and obscure verbiage, usually associated with bureaucratic pronouncements." Gobbledygook evidently has survival value: It flourishes, and not only among administrative bureaucrats:

> "The Big Trouble with Scientific Writing * * *. When I see articles, as I frequently do these days, exhorting authors to greater simplicity and clarity, I think of the first little scientific note I wrote, when I was an idealistic graduate student. I wrote it as simply and directly as I could. It began, "The big trouble with diffusion cloud chambers is low radiation resistance," and it went on in the same vein. My coworkers thought it needed a little more work. Secretly I did not agree, so I decided to attempt to make it into a parody of scientific writing. I borrowed impressive but empty phrases from "The Review of Scientific Instruments." Each sentence and each idea was made unnecessarily complicated, without being too obvious about it. The result began, "The principal difficulty encountered in the operation of an ordinary high-pressure hydrogen cloud chamber is inferior radiation resistance." I failed in my attempt, for now everyone thought it read fine, and it appeared in its complicated form in "The Review."
>
> My point is not that scientific writing cannot be parodied, but rather that scientific writing is the way it is because its readers actually prefer it that way. People's actions do not always correspond to their words. Everyone is against sin and bad writing, unless given a free choice. (Letter to editor, "Science," Sept. 22, 1967, p. 1374–5, from Robert H. Good, Department of Physics, California State College, Hayward 94542.)

We have said that reports of specialized aspects of the earth sciences perhaps cannot be written in the "language of the people," but there should be no place in any type of Survey writing for what is commonly spoken of as "gobbledygook." Scientific gobbledygook is no less gobbledygook for being scientific. (Throughout STA 6, examples of poor usage are given on the left, correct or better usage on the right. Examples given only to illustrate a point run across the page.)

The distribution and physical relationships of the XYZ Formation relative to subjacent rocks suggest that it was deposited in a restricted area over which a particular set of paleogeographic and tectonic conditions existed. The occurrences of quartz sandstone of age and physical attributes similar to those of the XYZ Formation at certain places to the south and southwest of North Valley, however, indicate that such conditions obtained locally elsewhere in western Nevada.	(Does author mean: South and southwest of North Valley, the occurrence of sandstone similar to the XYZ Formation indicates that geographic and tectonic conditions similar to those of the depositional area of the XYZ existed locally elsewhere in western Nevada.)
A general loss of strength enabled the sediments to undergo flowlike displacement in a downslope direction.	Loss of strength caused the sediments to flow downslope.
The foundation materials underwent a kind of flowage in which there was rearrangement of the materials at the intergranular level.	The grains of the foundation materials were rearranged by a flowlike movement.
The daily march of photosynthesis differs from the daily march of insolation by being relatively lower in the afternoon hours.	Photosynthesis differs from insolation by decreasing in the afternoon.
The upward component of movement was distributed throughout the sediments.	The sediments moved upward.
On the basis of this theory, displacements on the thrust faults are of the order of a few miles such that blocks of the ABC Formation have not been moved far from the original sites of deposition of the sediments.	(Does author mean: According to this theory, thrust faulting has moved blocks of the ABC Formation no more than a few miles from the original sites of deposition of the sediments.)
It is unlikely that the PQR Formation is absent above Unit II due to less probability for preservation there than over Units I and III, because the deformation of rocks in Unit II is less than in Units I and III and because of the overriding of Unit II by Units I and III. The evidence suggests that the PQR Formation was not deposited on Unit II.	(Does the author mean: The facts (a) that Unit II is less deformed than Units I and III and (b) that it is overridden by them suggest that the PQR Formation was not deposited on Unit II.)
One of the most interesting cases illustrated an instance of what seemed to be a puzzling case of vertical bedding.	(Does the author mean: A puzzling feature of the deposit was the apparent vertical bedding at one place.)

More detailed discussions of "inflated, involved, and obscure verbiage" and how to avoid it are given in the two volumes of "Effective Revenue Writing" of the Internal Revenue Service (IRS 1 [1961]; IRS 2 [1962]), O'Hayre [1966?], and Bell Telephone Laboratories (1967, p. 8–9).

REFERENCES

Bell Telephone Laboratories, 1967, Editorial style guide (2d ed.): Whippany, N.J., Editing-Production Group, 108 p.

The Bell Laboratories guide was prepared for internal use. It is written in the "underlying belief * * * that technical manuscripts need not be dull, uninspired, jargon-ridden tracts inherently to be deprived of the refinements of the English language. On the contrary, technical literature can make as effective use of the splendid flexibility and variety of English as can any other discipline" (p. iii).

McKelvey, V. E., 1973, Wanted: Usable, credible information—plain if not simple: Address to Geological Society of America, Southeastern Section, Knoxville, Tenn., April 12, 1973.

O'Hayre, John, [1966?], Gobbledygook has gotta go: U.S. Bureau of Land Management, 113 p.

A light-hearted malediction on governmental obfuscation.

Smith, G. O., 1915, Plain writing: Science, new ser., v. 42, p. 630–632.

A slightly modified version of this paper, retitled "Plain Geology," was published in 1974 by the U.S. Geological Survey in its pamphlet series.

Strunk, William, Jr., revised by E. B. White, 1972, The elements of style (2d ed.): New York, Macmillan, 78 p.

Strunk and White (p. viii) attempt to give in a stringently brief space and manner "the principal requirements of plain English style." The "requirements" are somewhat subjective, but if Mr. Strunk had been able to enforce universally his command to "Omit needless words," carloads of paper and acres of forest would be saved daily.

Tichy, H. J., 1966, Effective writing for engineers, managers, scientists: New York, John Wiley, 337 p.

U.S. Geological Survey, 1958. Suggestions to authors of the reports of the United States Geological Survey (5th ed.): 255 p.

U.S. Treasury Department Internal Revenue Service [1961], Effective Revenue writing 1: 261 p.; [1962], Effective Revenue writing 2: 198 p.

The complementary texts of the Internal Revenue Service training course in the elements of good writing are two of many government manuals and guides to written communication. IRS 1 is "a basic course designed to give a brief, practical review of writing principles, grammar, and punctuation (title page)." IRS 2 is a highly literate and readable work written by Calvin D. Linton, former Dean of Columbian College of George Washington University. Mr. Linton took as his thesis the fact that "writing skill is quite independent of areas of special knowledge" (p. 10). Superior knowledge of a subject, he held, does not of itself mean greater writing skill.

AIDS FOR WRITERS

The author ambitious to become a proficient technical writer should become familiar with more than one dictionary and more than one authority on style and grammar, both to reinforce his own self confidence and to understand that, on some points, language and editorial authorities may differ as diametrically as do earth-science authorities. A few such aids that the authors of STA 6 have found helpful have been cited (p. 13); some others are listed below. The lists are neither comprehensive nor exhaustive. Any technical library will have many more, and perhaps even more helpful, similar publications.

DICTIONARIES

An unabridged dictionary is always a writer's first aid. The serious writer must have access to one, and preferably to more than one. The "Oxford English Dictionary" (1933; Oxford University Press, 13 v.) is the most exhaustive study of the English vocabulary ever published, but it is too exhaustive and too massive to be a practical aid to the average author. The Merriam-Websters (WNI 2, 1934; WNI 3, 1961), Funk and Wagnalls (1959), and Random House (1966) unabridgeds are of more manageable size and scope.

The GPO style manual (1973, p. 61) specifies "Webster's Third New International Dictionary" as the official guide for spelling in government publications unless otherwise indicated in the manual. As Bell Laboratories (1967, p. IX) notes, "The third edition contains much up-to-date information but, unlike the second, does not draw distinctions between the acceptable and the current. As a consequence, the reader seeking answers to questions on preferred usages will find the second edition more helpful."

The second edition of Merriam-Webster (WNI 2) is out of print, but many offices have foresightedly saved their old seconds while providing their workers with new thirds; fortunate the writer who has access to both the old and the new unabridged Websters. WNI 2 includes an informative "History of the English Language" (p. lxxxii–xc). WNI 3 has a discussion of all currently used punctuation marks (p. 48a–51a)

and also gives detailed spelling rules that include construction of plurals and word compounding (p. 23a–28a). Not all the spelling and compounding rules of WNI 3 agree with GPO style-manual preferences.

The Random House unabridged contains lists of common French, Spanish, Italian, and German words and their English equivalents and also a 64-page multicolored atlas of the world.

"The American Heritage Dictionary of the English Language" (William Morris, ed., 1969, New York, Houghton Mifflin, 1,550 p.) is not unabridged, but its scope is wide and its material is readable and informative. For writers who feel more comfortable with an authoritarian dictionary to lean on, American Heritage tries (p. vi) to "add the essential dimension of guidance, that sensible guidance toward grace and precision which intelligent people seek in a dictionary."

"The vocabulary recorded here, ranging from the language of Shakespeare to the idiom of the present day, is that of the educated adult," according to Heritage's editor (p. vii). Some of the dictionary's definitions include brief "usage" discussions obtained by the novel method of "careful tabulation and analysis" of questionnaire-replies from " a panel of 100 outstanding speakers and writers * * *. As a consequence, this Dictionary * * * [offers] the reader the lexical opinions of a large group of highly sophisticated fellow citizens" (p. vii).

After the unabridged dictionary, the next most useful reference may be a thesaurus (from the Latin for "storehouse" or "treasury"). Several modern versions of Peter Mark Roget's thesaurus, first published in 1852, are on the market. Thomas Y. Crowell Co.'s third edition was published in New York in 1962 (1,258 p.); St. Martin's Press, New York, published "The Original Roget's Thesaurus of English Words and Phrases" in 1965 (1,405 p.).

A thesaurus is a great help in running down a word that the writer is groping for but can't quite remember. It is also a help in avoiding undesirable word repetition, though it is not a dictionary of synonyms; it is rather a listing of all conceivable substitutes for given words, many of which may not be acceptable or applicable. A thesaurus should be used in conjunction with an unabridged dictionary or with an aid such as "Webster's New Dictionary of Synonyms" (1968, Springfield, Mass., Merriam, 909 p.), which is "a dictionary of discriminated synonyms with antonyms and analogous and contrasted words" (title page).

Word Guides

Most writers sooner or later become attached to a favorite word guide which, as time goes on, becomes more and more infallible to them. These guides all contain helpful and interesting information about

English words. Most of them also contain some of their writers personal preferences and prejudices concerning certain words. The Survey writer should not become too dependent on any one guide.

Evans, Bergen, and Evans, Cornelia, 1957, A dictionary of contemporary American usage: New York, Random House, 567 p.

The Evans volume contains much detailed discussion of troublesome words, phrases, and grammatical usages. Some of the opinions expressed are advanced and permissive and are not accepted by other authorities; see for instance, the discussion of participles (p. 353–355).

Follett, Wilson, 1966, Modern American usage: New York, Hill and Wang, 436 p.

An erudite and readable compilation of fine points and fine distinctions of American-English usage. Follett is not permissive and he does not hesitate to express disapproval of what he considers undesirable usage, but neither does he command the tide to stand still; rather he advises those who dislike salt water to quietly avoid the seashore (p. 105): "Persons old enough to have been repelled by the verb 'contact' when it was still a crude neologism may as well make up their minds that there is no way to arrest or reverse the tide of its popularity. * * * [But the conservative does retain] one advantage: no one insists that he must use 'contact,' and if he sticks to 'consult' and other inconspicuous synonyms no one will even notice his abstention."

The book contains detailed and useful discussions of "adverbs, vexatious" and of punctuation; however, the 22 pages on usage of "shall (should), will (would)" need not unduly concern Survey authors.

Fowler, H. W., revised by Ernest Gowers, 1965, A dictionary of modern English usage (2d ed.): London, Oxford University Press, 725 p.

"Fowler," first published in 1925, has been cherished by generations of Survey authors and editors. Never mind that its diagonals and ampersands were confusingly numerous, that its syntax was obfuscatory, and that many of its dictums were arbitrary and personal; it was accepted as authoritative. "Fowler says * * *" was enough to settle any argument about word usge. The Gowers revision is perhaps less flavorful, but its syntax is less ponderous, its style is more graceful, and its opinions are less didactic.

Funk & Wagnalls Editorial Staff, 1953, Standard handbook of prepositions, conjunctions, relative pronouns, and adverbs: New York, Funk & Wagnalls, 116 p.

Sentence clarity depends on careful choice of connectives (conjunctions, conjunctive adverbs, relative pronouns, and prepositions). This handbook gives the derivation and usage of English connectives. It includes an extensive list of phrasal prepositions and an alphabetical list of more than 2,000 prepositional idioms, each illustrated as to sentence usage.

Grammar and Style Guides

Flesch, Rudolph, 1946, The art of plain talk: New York, Harper, 210 p.

Proposes a system of "readability tests."

Kierzek, J. M., and Gibson, Walker, 1965, The Macmillan handbook of English (5th ed.): New York, Macmillan, 493 p.

The Macmillan handbook is aimed at comprehensive coverage of English problems of college freshmen: parts of speech, parts of the sentence, punctuation, spelling, sentence and paragraph structure, how to use the library, how to compile a bibliography, how to write a research paper. It is an excellent reference and review for writers whose freshman courses are some years behind them.

National Academy of Sciences, 1971, A guide for preparing manuscripts: Washington, D.C., 60 p.

"This handbook was prepared in response to continuing requests for a guide to serve the many persons involved in the preparation of manuscripts for publication by the National Academy of Sciences, the National Academy of Engineering, and the National Research Council" (quoted from "Acknowledgments," unpaged).

Skillin, M. E., Gay, R. M., and others, 1974, Words into type (3d ed.): Englewood Cliffs, N.J., Prentice-Hall, 585 p.

A voluminously detailed, comprehensive guide for editors that literally begins with the typing of the manuscript and follows through to selection of type for the printed publication. Includes advice on abbreviations, capitalization, punctuation (22 pages of discussion and examples of proper use of commas!), grammar, the right preposition, trite expressions, wordiness, and typography and illustrations. The book is written as instructions for editors, but author-readers will find much useful information, and novice author-readers particularly can acquire some comprehension of the multifaceted editorial and compositional processes by which their manuscript words are transformed into printed pages.

University of Chicago Press, 1969, A manual of style (12th ed., revised): Chicago, 546 p.

The venerable and widely respected Chicago "Manual of Style" was revised in its 12th edition "to stress fundamentals that in the past may have been taken for granted, to illustrate every principle enunciated as fully as possible, and in all instances to advocate the simple and economical in place of the elaborate and expensive" (p. vii). The manual is more concerned with humanistic than with scientific technical style, but it has a wealth of detailed recommendations on reference lists and citations, capitalization, indexing, construction of tables, and other authorial and editorial matters that are of common concern throughout the publishing industry. Some of the recommendations of the Chicago manual differ from Survey style, but the authors of the manual make clear that their directions and recommendations are not necessarily the only or even the best ways; they are simply the preferences of the Universiy of Chicago Press.

MISCELLANEOUS

Bartlett, John, 1968, Familiar quotations (14th ed.): Boston, Little, Brown, 1,750 p.

The writer thinking of embellishing his heavy scientific data with a pertinent literary quotation should always check that his quotation is exact, else he and the Survey will get embarrassing letters pointing out his inexactitude.

PLANNING AND STARTING THE REPORT

Notes on original field or laboratory observations should be sufficiently explicit and neat that they are meaningful both to the author, who may not transform them into a final report for months or years, and also, if necessary, to someone who took no part in the project. A few greats of geology have been known to prepare their field notes and sketches so meticulously that substantial parts could be transformed directly into final manuscript. A little time spent in the Field Records Center of the Survey Library at Denver consulting the field notes of F. L. Ransome and G. K. Gilbert, for example, would be a rewarding experience for the aspiring young writer of geological reports.

Ideally, notes should record not only observations but also the note-taker's preliminary impressions, tentative generalizations, and even incipient theories and hypotheses. Most thoughts of this nature will change radically as additional observations are amassed, but all will serve as stimuli and guides for further thought.

Plans for the project report should be formulated, in writing, by the researcher in consultation with his supervisor (and with his coworkers, if any) at the outset of the project. Such plans will change as the work progresses, but a vision of the form in which the project results are expected to be reported will save time, effort, and expense and may avoid acute disappointment. Authors have been known to submit a full-sized book-type report when only a geologic map with brief text or a short paper for journal publication was the desired product.

These early plans should include an estimate of the time needed to complete the report: Make the most realistic estimate possible, then double it; use the result as the minimum time needed for the job. This pessimistic estimate will be a movable, and probably receding, target, but it will be part of the time and cost guides that both author and supervisor need for management.

The First Step

The generally recommended first step in the actual compilation of the report is to make a preliminary outline, which will be a help in organizing thought and in identifying gaps in data and, as it evolves,

will serve as a measuring stick of progress on the project. This original outline will probably consist of the headings of the main units of the report. As work progresses, the outline can be refined and fleshed out with headings of the subunits.

The preliminary-outline procedure is useful to the fortunate majority of writers who have orderly, logical minds that have no difficulty in starting with step 1 and going to step 2 and thence in sequence to the end of the way; but it is not for all authors. For the less orderly minded author who may be able to formulate no more than a disordered mental list of the topic he intends to cover, we repeat our earlier advice: Work and write as you work and write best; start with whatever point seems easiest to put on paper. But start. Tichy (1966, p. 17–63) has some pungent and pertinent comments on "Getting Started"; she lists "Two Dozen Ways to Begin." But as the only way to write is to write, the only effective way to start is to start. Just be sure that the final product is outlineable, that the table of contents, drawn up from the unit headings and subheadings, will fall into a rational order.

The writer who can prepare a preliminary outline for his report will probably also be able, and will find it helpful, to prepare a preliminary abstract. This abstract, like the outline, will bear little resemblance to the final product, but the labor of boiling his findings down to a few hundred words will force the author to view all his research in perspective and to begin to differentiate between the important and the trivial. He will thus provide himself with guidance on proper relative emphasis in the different facets of the writing job ahead.

Another step the prospective author should take early is to plan for access to needed references, glossaries, gazetteers, and the like. Some he may own; many others will be in libraries. If particular references are not in Survey libraries, the library may arrange to borrow them from other libraries or may purchase them for the Survey collection. A few commonly used references are listed at the end of this section; others are listed at the ends of sections pertaining to various special subjects.

Parallel Chores

Illustrations and text are so closely interdependent that tentative plans for illustrations, like plans for the text, should begin at the beginning of a research project, and preparation of the illustrations should proceed in parallel with that of the text. Much of the text indeed will consist of descriptions or interpretations of what the illustrations show. Too, many ideas come to an author, or begin to crystallize, while he is collecting specimens, drawing his maps or sketches, studying and

refining his rough drafts of illustrations, or analyzing laboratory reports.

A list of all those who have contributed to the author's work should be maintained from the beginning of the research. Many of the names will be omitted from the final acknowledgments, but without a running list the author can easily forget some of the people to whom he is indebted.

It is the author's responsibility to secure the permission of the owner of any copyrighted material that is to be quoted in the report. Such permission is usually given freely for use in scientific publications, though some publishers require specific forms of acknowledgment. Copies of the copyright permissions must be forwarded with the manuscript when it is submitted for the Director's approval for publication. Federal Government publications are not copyrighted, nor may a journal or other outside publisher claim copyright on material written by a government employee as part of his official work. Thus, Survey publications are, in effect, in the public domain and may be reproduced by anyone who wishes to do so. However, the Survey and also individual Survey authors sometimes receive requests for permission to republish part or all of a Survey-generated paper. Such requests are of course always acknowledged and granted, but it is customary to ask that the Survey be mentioned as the source of any quotation or information.

Geologic names (except astrogeologic names) used in Survey reports are routinely reviewed by the Survey's Geologic Names Committee, but if the writer plans to introduce new geologic names or to alter existing ones, he is well-advised to reserve his proposed nomenclature with the Committee as early in the report preparation as possible (see p. 132, 133, 134). In addition to checking usage by Survey authors, the Committee, if requested, also checks usages and reserves new names for non-Survey authors.

The U.S. Board of Geographic Names is the final authority on place-name usage in all official U.S. Government publications. It passes on all proposals for new geographic names and for changes in existing names for geographic features. If the author plans to introduce new geographic names or to make name changes, he should request Board approval early in the report-preparation process (see p. 160).

Use of proposed new mineral names also must be approved in advance of publication. This authority rests with the Commission on New Minerals and Mineral Names, International Minerological Association. The author may forward his request for approval through his organizational channels or he may write directly to the Commission, whose current address (chairman and secretaries change!) will be obtainable from the Mineralogical Society of America, 1909 K Street, NW., Washington, D.C. 20036.

A card-record bibliography of all the literature cited and consulted during the research and writing stages of a project will be most valuable. If each reference is entered on a separate card, in proper bibliographic format and with annotations, compilation of a final bibliography will be routine, as will standardization of citations throughout the text. Last-minute corrections and fill-ins of missing references will be eliminated. It is also well to maintain running lists of tables, illustrations, and other additions to the text matter as these planned or prepared. Deletion of unused or abandoned items is much easier than derivation of a new list as the report approaches completion.

Disposal of the field, library, and laboratory notes, the maps, photographs, specimens, thin and polished sections, and the correspondence must be made at some point after publication of a report. Procedures for disposal of these raw materials vary widely among Survey branches and Divisions, and ultimate disposal will depend to some extent on the author's future work. The better the labeling, indexing, and arrangement of the materials, the easier will be the writer's job in reusing them and the more useful will they be to other users of the archives.

Reference

Tichy, H. J., 1966, Effective writing for engineers, managers, scientists: New York, John Wiley, 337 p.

Additional Aids

Baker, B. B., Jr., and others, eds., 1966, Glossary of oceanographic terms: U.S. Naval Oceanographic Office Special Publication 35, 204 p.

Gary, Margaret, McAfee, Robert, Jr., and Wolf, C. L., eds., 1972, Glossary of geology: Washington, American Geological Institute, 805 p.

Most voluminous work of its type available. Contains definitions of about 33,000 earth-science terms and a long (52 pages) bibliography of sources, though does not identify definitions with sources. Gives synonyms with each definition.

Lapedes, D. N., ed., 1974, McGraw-Hill dictionary of scientific and technical terms: New York, McGraw-Hill, 1,634 p. and appendix.

Lists and defines almost 100,000 scientific and technical terms. Appendix contains tables of metric conversions, mathematical signs and symbols, and international graphic symbols.

Runcorn, S. K., and others, eds., 1967, International dictionary of geophysics * * *: Oxford, Pergamon Press, 2 v., 1728 p. (paged continuously).

"International dictionary of geophysics, seismology, geomagnetism, aeronomy, oceanography, geodesy, gravity, marine geophysics, meteorology, the Earth as a planet and its evolution" (title page).

Seltzer, L. E., ed., 1962, The Columbia Lippincott gazetteer of the world: New York, Columbia University Press, 2,148 p. and supplement.

"The spelling of geographic names must conform to the decisions of the U.S. Board on Geographic Names. In the absence of such a decision, the U.S. Directory of Post Offices is to be used for names of post office in the United States and its possessions, and the Columbia Lippincott Gazetteer of the World is to be followed in the spelling of other names" (GPO style manual, 1973, p. 70).

Thrush, Paul W., and the Staff of the Bureau of Mines, eds., 1968, A dictionary of mining, mineral, and related terms: Washington, U.S. Government Printing Office, 1,269 p.

This volume, which contains definitions of about 55,000 terms related to mining and the mineral industries, is a revision of "Fay's glossary," first published in 1918 as Bureau of Mines Bulletin 95, "A Glossary of the Mining and Mineral Industry." The editors have followed the pattern established in Bulletin 95 of defining terms by quoting from identified sources.

The U.S. Postal Service annually publishes a "Directory of Post Offices", which includes zip codes. The National Railway Publishing Co. of New York publishes official railway guides bimonthly; certain editions include all North American freight stops.

THE PARTS OF THE REPORT

TITLE PAGE

The title page of a Survey book report carries the title, name of author or authors, statement of cooperation if applicable, and a brief statement characterizing the report. The title and authorship are also typed on the first page of text above the abstract, about 2 inches from the top of the manuscript page to allow space for directions to the printer and for volume title if needed.

Title

The title should be as brief as it can be made, consistent with clarity; it should not serve as a summary of the report. Long, long titles do not necessarily mean deep, deep study—and usually they are not quoted in entirety. But use of several unit modifiers or of a pyramid of prefixes in an attempt to shorten the title should be avoided. The title "Neogene Geochronobioclimatopaleomagnetostratigraphy: A Mediterranean Synthesis," for example, contains only five words, but some readers may think it a bit overdone for a 250-word abstract.

Most Survey authors avoid beginning their titles with such words as "The," "A," "Notes on," and "On." These words sometimes can be used effectively to begin text headings, but in a book title a more significant word is usually preferable.

The titles of many Survey reports are of certain types, as:

Stratigraphy of Paleozoic Rocks in the Carlin-Pinon Range Area, Nevada

Mineral Resources of the San Pedro Parks Wilderness and Vicinity, Rio Arriba and Sandoval Counties, New Mexico

Surface Water Supply of the United States, 1966–70, Part 4, St. Lawrence River Basin

Geology of the Sage and Kemmerer 15-minute Quadrangle, Lincoln County, Wyoming

Floods of September-October 1967 in South Texas and Northeastern Mexico

Ground Water in the Corvallis-Albany Area, Central Willamette Valley, Oregon

For many reports, however, there are no such guidelines, and the author must devise a satisfactory title.

Authorship

Assignment of authorship responsibilities is an extension of the divisions of responsibility that have characterized the research project from its inception. Final decisions on this sensitive matter will be made by the project chief or his supervisor on the basis of evaluations of the relative contributions of collaborators and on their ability to deliver assigned segments of the joint manuscript. For any research project that involves more than one scientist, however, it is most desirable that each worker have a clear understanding at the outset of the project as to exactly what part of the research is his responsibility and what part of the final report he is to prepare.

The person or persons who had immediate and active charge of the investigation or who prepared the report or map will naturally be named as the author or among the authors of the report. Other coauthorship is restricted normally to those who contributed very substantially to the conduct and results of the investigation. Usually those individuals in more general administrative or supervisory control over the investigation or those who, as members of the party or group carrying out the investigation, performed only routine technical assistance, are not included as coauthors.

Seniority, grade, and like distinctions should not be the primary criteria in deciding on authorship or coauthorship nor on whether a contributor should be listed on the title page, in the section on acknowledgements, or in a table that records laboratory results. Instead, the degrees of credit should be based on degrees of responsibility for the finished product and for the work and thought that went into it. Contributions of laboratory assistants and other support personnel are more commonly credited in text or tables, but if the assistant has played a large role in a research investigation there is no reason why he should not be listed as coauthor or, more rarely, even as senior author.

In Survey reports, there is seldom justification for naming more than four principal authors for a single report. However, in a single report covering principal or major work by one or more named authors, a supplemental or subordinate contribution on a related phase may be credited by adding to the main title and authorship the words "With a section on (subject), *by* (author)." The form "*by* A, B, C, and others" is sometimes used.

The author of each single titled report will be named regardless of whether the report is published as a complete numbered publication or as one of several chapters published under a more general title indicating topical or geographic relationship.

The listing of multiple authors for a single report causes problems for supervisors, editors, librarians, bibliographers, and even promotion boards. But in an age of increasing specialization and of multidisciplinary group efforts, many reports are prepared through the joint efforts of several authors, and those who have performed a particular segment of a joint research effort should have the responsibility and get the credit for writing up the results. The problem may be greatly reduced by skillful, generous use of the section on acknowledgments. The listing of six or seven authors for a six- or seven-page report may seem a little ridiculous to the reader, and it seems even more ridiculous in a 200-word-limit abstract journal.

Statement of cooperation

If the project was undertaken in cooperation with other Federal agencies or with State or other governmental agencies, the cooperation is expressed by statements on separately published maps and on the title pages and the covers of book reports. Some examples from recent Survey reports and maps are:

Prepared on behalf of the National Aeronautics and Space Administration
Prepared in cooperation with the U.S. Army Corps of Engineers, Mobile District
Prepared in cooperation with the Colorado Department of Natural Resources
Prepared in cooperation with the States of Illinois, Indiana, Kentucky, and Tennessee, and with other agencies

If the sponsor or cooperating organization desires some other form of acknowledgment, its wishes should be followed. The author is responsible for ascertaining the exact title of the cooperating agency for such statements of cooperation.

Descriptive statement

A brief statement characterizing the report should be placed on the title page of the manuscript when it goes forward for final review and approval. Examples of these descriptive statements from recent Survey reports are:

A study of the distribution of elements in two Continental Shelf environments of different depositional character
The Figuera Lava and the overlying Fajardo Formation are redescribed and assigned to the Lower Cretaceous Series.
A history of land subsidence caused by water-level decline in the San Joaquin Valley from the 1920's to 1972
A stratigraphic-paleontologic study of rugose corals as aids in age determination of Great Basin Devonian rocks

Front Matter

Foreword and preface

The foreword is a statement concerning the report by someone other than the author; the preface is a statement by the author himself. Both precede the table of contents, the preface after the foreword if a report has both. Most Survey publications have little need for either a foreword or a preface. Care in preparing the introductory material generally will eliminate the need for a preface, and few reports need any comment other than the author's text. However, there are circumstances in which prefatory statements are appropriate: (a) A publication may be unusually important, (b) it may consist of a collection of papers, each having its own author and title but pertaining to a central theme reflected in the title of the volume, or (c) it may be the report of a cooperative investigation by the Survey and another governmental agency. Such publications may benefit by a foreword, written and signed by an administrative official, in which the importance and circumstances of the investigation are described.

A preface can be used to provide a prominent place for bibliographic information, such as the relation to other editions of the same report and to other reports on the same subject, and also for certain kinds of credits and acknowledgments that are not included on the title page. In organization-type reports, for example those on surface-water supply of the United States, the preface can give credit to those who supplied data and who in other types of reports would be recognized as authors. A preface may be unsigned or it may carry the name or initials of the author.

"Contents," "Illustrations," and "Tables"

The manuscript should include lists of "Contents," "Illustrations," and "Tables." The "Contents" should consist of the headings appearing in the manuscript, except for repeated minor headings, which are omitted from "Contents." Rank of the headings should be indicated by appropriate indention under the preceding related headings. The "Page" column should show final manuscript page numbers. All illustrations should be listed as figures in the manuscript; they will be separated into plates and figures by the illustrators in cooperation with the editors, who will then make the necessary changes in the manuscript. An exception to this rule is the paleontologist's preparation of plates on which he groups figures that show photographs or drawings of individual fossils.

Specimen lists of "Contents," "Illustrations," and "Tables" follow. The "Contents" will be recognized as a de facto outline of the report.

CONTENTS

ILLUSTRATIONS

TABLES

ABSTRACT

Except for certain statistical reports and composite group efforts that may be unsuitable for the usual informative type of abstract, any but the briefest published scientific paper is preceded by an abstract; a proposal to present a paper orally must also be accompanied by an abstract.

The abstract is a digest of the report, and on its adequacy will depend much of the report's impact, durability, and usefulness. The busy reader may not read the text at all unless he has been led to it by the abstract. Too, the abstract will appear in abstract journals and indexing services and will thus increase the potential audience and the reference value in the literature. For an oral presentation, the adequacy of the written abstract will probably determine whether the author is even permitted to give his paper and, if so, whether he will draw an audience.

Some water-resources reports by their nature require a descriptive abstract, but for most Survey reports the abstract should specify the problem or the project and should briefly state the conclusions or results. It should be informative rather than descriptive; "* * * are discussed," "* * * was investigated," "conclusions are given" are generally inappropriate phrases for an abstract. What the report tells should be stated, not what it is about. For example:

Write "Holocene movement along the late Mesozoic faults occurred * * *," not "Subsequent movements along old faults are identified * * *."

Write "By this sensitive method, 10^{-8} g of uranium can be detected," not "The sensitivity of the method is high."

Write "A gravity high of 25 milligals suggests that * * *," not "The gravity anomalies in the area are discussed."

Write "The Cretaceous rocks yield 50 to 150 gpm of moderately mineralized water to wells 800 to 1,200 feet deep," not "Ground water in the Cretaceous rocks is described."

The abstract should indicate the method of attack and the type of data used and should clearly orient the paper in place and in function. It should supplement, not duplicate, the title in this respect and should not be merely an expression of the table of contents.

Few abstracts will be long enough or complex enough to need center headings, and few will need to be amplified by examples.

The abstract should be a complete unit, independent of the text. For this reason, reference to text tables, illustrations, and bibliography should be avoided. Rarely, an abstract may require reference to a published work; then the complete citation should be given in parentheses, not just the usual text reference to author and year of publication. No information should be given in the abstract that is not discussed in the report.

Except for papers in the Journal of Research, the Survey sets no specific limit on length for the abstract in its publications, either by total number of words or by percentage of length of text, but the

shorter the abstract the more likely it is to be read and to be included in abstract journals in its entirety and in the author's original words. Rigid limits on words or on space used are generally imposed for abstracts offered to scientific meetings; to exceed the stated limits is to risk rejection of the proffered paper.

Early rough-draft summaries are probably helpful to the author in the planning phases of report writing, but the final abstract can only be written after the manuscript is complete. Production of a good abstract—one which summarizes all the important content of the report and nothing else—deserves more care and more rewriting and polishing than any other part of the author's job.

Landes (1966, p. 1992) has written some relevant and readable paragraphs on construction of an abstract.

Reference

Landes, K. K., 1966, A scrutiny of the abstract: Bulletin of the American Association of Petroleum Geologists, v. 50, no. 9, 8 p.

TEXT

Like all forms of well-written composition, well-written Survey textual reports have a beginning, a middle, and an end—an introduction, a discussion or presentation of data, and a conclusion. These parts may appear under different names, or under no names at all if the report is short; they may also appear in many different formats and lengths. Texts that accompany maps generally consist only of discussion or presentation of data; they seldom require abstract, introduction, or conclusion.

The beginning

The introduction of book reports will include, as needed, (a) a statement of the purpose of the investigation, (b) the conditions under which the work was done, (c) the plan of treatment of the subject matter, (d) acknowledgment of cooperation and help, (e) a summary of previous work in the field, and (f) notes on the most important prior publications.

The introduction may call attention to the author's outstanding conclusion on local or regional problems or on the further development of current theories and to any noteworthy differences between his conclusions and those expressed in earlier publications.

If geographic description of an area being studied is needed, a brief statement of the location, routes of approach, topography, climate, vegetation, and other features will suffice. Detailed information on these subjects will be needed in very few reports.

One "Introduction" and one "Summary" generally are enough for a single report; if a summary of one of the subdivisions seems desirable, the heading should indicate the subject discussed, as "Summary of Conditions Affecting Streamflow."

All technical and professional help from non-Survey personnel should be acknowledged, but it is usually unnecessary to mention general help given by other members of the Survey. Every Survey investigation and report has had the benefit of suggestions by the author's colleagues as a routine part of their work, and such assistance need not be recounted unless it is a noteworthy contribution to the investigation or report. If acknowledgment is to be made, an unadorned statement of the specific aid given will help fix responsibility and will probably be more pleasing to the recipient than an effusive expression of gratitude. "John Smith gave me access to his unpublished data on the ABC area of the XYZ quadrangle" is more informative than "I am extremely grateful to John Smith for the unselfish help he gave me during the compilation of this report."

Specific pieces of work by either Survey or non-Survey personnel, such as analyses, computations, and identifications of minerals and fossils, must be credited to those who made them. Such credits should be carried in the tables, lists, or statements in which the work is reported, not in the formal "Acknowledgments" paragraph. This credit is courteous, it is honest, it fixes responsibility, and it is mandatory for Survey reports.

If photographs other than the author's own are used, acknowledgment should be made of the photographer, by name, as part of the caption of each such illustration.

Family members, typists, editors, illustrators, librarians, and others contribute in many ways to the production of nearly all manuscripts. Letters of appreciation to the administrative and technical employees' supervisors are more suitable and probably more immediately profitable to the individuals than mention in a technical paper; thanks for help from family members can be expressed in personal ways.

For acknowledgments and other occasions of personal reference, the preferred form is "Joseph P. Smith" or "Mary M. Smith" the first time the person is referred to; thereafter "Smith" or "Mr., Mrs., Miss, or Ms. Smith" is used, as applicable or preferred. Usage should be consistent; don't use "Smith" in one paragraph and "Mr. Smith" in the next. Military and political titles ("Colonel," "Senator") are used in Survey papers, but academic and professional titles ("Doctor," "Professor") are omitted.

Presentation of data

The main body of most reports, that is, the presentation and discussion of data, has certain common features (headings, footnotes, illustrations, tables, geologic names, geographic names, significant figures,

indexes) which warrant some detailed suggestions, as given below and in following sections.

Headings

Headings should be centered, typed in caps and lowercase, and not underlined. The "Table of Contents" will indicate the rank of headings by indention, and it will be a convenience to the editor if the author indicates by circled pencil mark in the manuscript whether the heading is of first, second, or third rank. The copy editor may find that certain headings should be italic sideheads, but this determination is better left to the editor.

The text should be complete and independent of headings. In general, headings will be noun phrases though, particularly in a popular-appeal type publication, short sentences may be effective.

Headings preferably should indicate the things described or discussed in the text; thus "discussion of," "statement of," and "table showing" are usually superfluous in headings.

Excessive refinement in subdividing the text confuses the reader; three or four ranks of centerheads, plus italic sideheads where applicable, should be sufficient. (The italic sidehead has no specific rank; it is a subordinate heading used for terms or phrases that may be repeated under higher ranking headings, as "Age," "Composition," and "Chemical analysis.")

Footnotes

Footnotes break the reader's train of thought; in scientific writing they are seldom needed except in the short paper having few references and no bibliographical list. A well-constructed paragraph should need no explanatory (in effect, parenthetical) footnote. Nor should the author make a footnote of a thought that came to him late and that he should have taken time to weave into his text. A rare instance in which a nonbibliographical footnote may be justified occurs when relevant contradictory or supplementary information becomes available after a manuscript is finished or in proof stage. Otherwise, footnotes are generally more appropriate to literary than to scientific writing.

The end

The terminal section of the report should be a concise statement about the principal points of the subject matter. In a short report the section may not need a separate heading—it may be just the last paragraph of the text. In a longer report it may be a "Conclusion (s)," "Ap-

plication to Field Problems," "Recommendation (s) for Further Study," "Summation of Petroleum Potential," or some other applicable form of ending.

The reference list

Most Survey book reports have a list of references, or a bibliography, which comes just after the conclusion of the text and before the appendix, if any, the list of tables or basic data, if any, and the index. Survey bibliographic style is discussed on pages 74–82.

The appendix, if any

Only rarely is an appendix used in a Survey publication. If the author decides that his long tables of analyses, well logs, or measured stratigraphic sections would interrupt the reader's train of thought if intruded into the body of the text, he may place them after the bibliography or list of references. Before the matter goes to the printer, the editor will supply a "half-title" page to indicate "Tables," "Basic Data," or whatever. In Survey writing, an appendix, if used at all, should be limited to specialized data that will be needed only by a few of the publication's potential readers. If the report contains more than one appendix, each should be numbered for ease of reference in the text.

Index

Survey indexes are alphabetized word by word, then letter by letter, on the principle that "nothing precedes something." (Some publishers index letter by letter; see University of Chicago Press, 1969, p. 415.) Thus the order of precedence in Survey indexes is:

East end
East Indies
Eastern time

Indexing is a technical, and tedious, editorial function but no part of the publishing process is more essential to a useful report, or more time saving to a busy reader, than a full, well-prepared index. All but the shortest reports, or those that by their arrangement or the nature of their subject matter do not need one, should have an index. The index is not part of the manuscript but is prepared by the editor from the page proof. The author, however, can help the editor by underlining, in page proof, words that he thinks should be indexed, or he can submit with his manuscript a list of terms that should not be missed when the index is prepared.

Authors of papers that are to be listed in a computer data bank may be asked to furnish a list of "descriptors" as selected from the index thesaurus of the agency operating the bank. If the author feels that terms not included in the thesaurus are needed for adequate indexing of his paper, most of the data-bank agencies welcome additional "identifiers," "key words," or "key terms." See, for example, any issue of the semimonthly "Selected Water Resources Abstracts" and the "Water Resources Thesaurus," both published by the Office of Water Resources, U.S. Department of the Interior.

Reference

University of Chicago Press, 1969, A manual of style (12th ed., revised): Chicago, 546 p.

ILLUSTRATIONS

By Ann C. Christiansen and Douglas M. Kinney

Planning

Illustrations for Survey book reports are broadly classified as plates and figures. "Plate" as here used is arbitrarily defined as any illustration that at publication size is larger than two facing pages. A "figure" is any illustration (color photograph, black-and-white photograph, or line drawing) that can be printed within the area of two facing pages. Photographs of fossils are, in Survey reports, usually labeled "plates" but are printed as page-size illustrations; however, they will be referred to as "figures" in this section.

The author should know the limitations of the publication series or the journal for which he is writing, such as page size, number and size of illustrations, or restrictions on use of plates, color or other reproduction processes. Such information can be obtained from the map editor, by inquiry of the journal editor, or by study of recent examples of the publication toward which the report is aimed.

The author should also know something about the relative costs of various printing methods; this knowledge may be a guide toward the most acceptable form for an illustration and may save months in publication delays. In general, the cost of line cuts (figures that can be printed directly with the text) is little if any more than the cost of composing and printing text; halftone black-and-white photographs cost only a little more than text or figures unless they must be printed on special paper or require special screening in reproduction. Color photographs or multicolor maps cost a great deal more than black and white, even if they are only page size, for they must be printed from two or more plates, separately from the text, and must be inserted by hand. Any plate is far more expensive and time consuming than a figure; color plates are many times more expensive to print than simple text and figures. These cost considerations disappear with large editions, such as those of popular magazines, but for scientific reports, which are rarely published in editions of more than a few thousand copies and which require precise registry of colors, they are very real.

In some Survey reports, particularly those on national parks or monuments and those prepared as popular publications, color photographs display the beauties of geologic features to the lay public; for these reports, color reproduction is essential and functional. Any use of color photographs in reports must be justified in writing; prior discussion and tentative approval of color illustrations may avoid much wasted work.

Planning for illustrations should begin when the research project itself is planned, or very soon thereafter. By using the preliminary project description and a rough outline of the ultimate report the author should be able to visualize the approximate kinds and numbers of illustrations needed. In consultation with the map editor or other advisor, more detailed plans for illustrations should then be made. This planning should explore, among other subjects,

1. Proposed publication series and its restraints
2. Need and justification for multicolor plates and photographs
3. Need for any separate plates that must be inserted in a pocket
4. Possibility of publishing some or all of the above plates in a separate map series
5. Dimensions of figures (see table below)
6. Frontispiece
7. Base-map requirements (see the following pages)

Publication sizes for book-report figures

	Picas	Centimeters	Inches
Professional Paper			
Column			
Bottom title	21×51	8.9×21.6	3½×8½
Side title	18×54	7.6×22.9	3×9
Page			
Bottom title	43×51	18.1×21.6	7⅛×8½
Side title	40×54	16.8×22.9	6⅝×9
3-Column			
Bottom title	64×51	27.0×21.6	10⅝×8½
Side title	58×54	24.4×22.9	9⅝×9
Double page			
Bottom title	86×51	36.2×21.6	14¼×8½
Side title	83×54	34.9×22.9	13¾×9
Bulletin or Water-Supply Paper			
Single page			
Bottom title	26½×39	11.1×16.5	4⅜×6½
Side title	23½×44	10.2×18.4	4×7¼
Double page			
Bottom title	53×39	22.2×16.5	8¾×6½
Side title	50×44	21.3×18.4	8⅜×7¼

Publication sizes for book-report figures—Continued

	Picas	Centimeters	Inches
Circular			
Column			
Bottom title	19×48	8.1×20.3	3¾6×8
Side title	16×52	6.8×21.9	2¹¹⁄16×8⅝
Page			
Bottom title	39×48	16.5×20.3	6½×8
Side title	36×52	15.2×21.9	6×8⅝

The most expensive single illustration that can be planned is a complex full-color map. It is therefore imperative that much thought go into the early planning of any geologic, geophysical, or hydrologic map. Necessary to early planning is consideration of the scale needed to show such detail as the aims of the project may require. That scale normally will determine the base map that will be used. Another factor is the necessity for publication on a topographic base; perhaps the initial mapping can be on topography, but publication can be on a reduced planimetric base. How much drainage and culture are necessary to allow the user to locate himself?

Yet another factor directly affecting the cost of preparation of the map is the need to portray information in color. If color is not necessary to the legibility of the map, color publication will not be approved. Generally speaking, however, it is less expensive to prepare copy for multicolor illustrations than to cut patterns for black-and-white or two-color printing to depict complex geology. The map editor can aid the author and the supervisor in determining the necessity for color on maps.

Before approval of a project that will require preparation of a map, discussion between the geologist, geophysicist or hydrologist, the map editor, and the branch chief or supervisor should determine the base to be used and the compilation and publication scale. Determination of the publication scale is fairly simple if published topographic base maps are available. At times the detail required for the solution of the geologic problems may necessitate an enlarged base map; at other times the lesser detail needed may suggest that several topographic bases be mosaicked and reduced, perhaps as much as 50 percent. (Fifty percent is the limit of reduction that retains legibility of geographic names on the base map.) Every effort should be made to judge accurately how much data should be acquired for publication; to secure more than can be published wastes time in gathering superfluous data, in selecting data to retain and data to delete, and in final drafting. For this reason, the map editor will recommend that the compilation and publication

scales be the same; strong justification is necessary to obtain a base map at a scale larger than will be approved for publication.

The author's final compilation must be on scale-stable material if data are to be registered to the available base map. The scale-stable base should be ordered several months before it is needed; even more lead time is necessary if the base is to be a mosaic of several topographic base maps or if it is to be at a scale different from the original base maps. The map editor can advise on the types of available stable materials; because new cartographic developments bring changed materials, no effort is made here to describe the types of materials currently available.

Figures may be either narrow measure (caption printed beneath the figure parallel to the rest of the text) or broad measure (turned sideways on the page and with the caption at the bottom of the figure as the page is turned sideways). The broad-measure, or side-title, figures are occasionally unavoidable, but they are awkward for the reader, who must turn the book in order to read them, and they make for unattractive pages. They should be avoided whenever possible. Consideration should be given to redesigning or reproportioning drawings or photographs, to using bleeds (extension of the photograph to the edge of the page and to the gutter) for oversized photographs, to placing explanations or captions on facing pages, or to using page-and-a-half or two-page spreads.

Standard image sizes for plates and oversize tables are given in the following table.

Centimeters	*Inches*	
106.7×142.2	42×56	
106.7×132.1	42×52	
104.1×132.1	41×56	
86.4×106.7	34×42	(GQ)
61.0×86.4	24×34	
50.8×81.3	20×32	
53.3×63.5	21×25	
50.8×63.5	20×25	
40.6×50.8	16×20	

The north orientation of all maps of the Geologic Quadrangle (GQ) series must be on the 86.4-cm dimension of the plate. North orientation of other maps may be on either dimension of the plate.

Preparation of Author Copy

Author's original copy for every illustration should be neat, clear, and accurate. It need not be finished copy, ready for printing, for virtually all illustrations are redrafted (but see "Stratigraphic Sections * * *," p. 65). Final drafting is done by the Publications Division after the report has been approved for publication, but the map editor or illus-

trator should be consulted during the preparatory stages to make sure that the author's copy is adequate for technical reviewers and illustrators. Final drafting of all illustrations generally is at publication scale.

All author's copy should be in black ink or in photographically reproducible pencil or it should be scribed. Colored inks should never be used. Lines should be no heavier than necessary; an author's heavy lines leave the exact placement of fine lines up to the illustrator, who should not determine positions of geologic features. Hand-lettering, if legible, is preferable for author's copy; the illustrator will place all final lettering.

Stick-on (zip) patterns are available for use on maps and cross sections. Choice and application of patterns are better left to the map editor and illustrator. For review copy of illustrations that are to be printed either in color or in black and white, areas to be patterned or colored are best indicated by colored pencil or ink on a paper or mylar print of the original drawing; never color the originals. Distinctive and contrasted colors should be used on review copy; if desired, a note to the illustrator may be attached to the "Check Sheet for Illustrations and Maps" with suggestions as to units to be emphasized, preferred colors, or published maps to be matched in final reproduction.

Illustrations must be complete when they leave the author. They must show all lines, symbols, numerals, letters, words, and limits of areas to be patterned or colored, and they must have explanations for symbols that are used on the illustration except the very common geologic map symbols shown on figure 1 (p. 63). Each illustration should stand alone without reference to text or to another illustration for explanation of symbols. The illustrator is an artist, but he can only trace the copy; he cannot be expected to supply missing lines or to interpret geology that may be clear to the author but is not clear on his illustration.

Captions

Captions (titles) of all illustrations, whether of plates or figures in books or of separately published maps or charts, must be both informative and concise. For separately published illustrations, as in one of the map series, the title should express content and location, and must be short; explanatory material is placed on the illustration itself, not in the title. Captions for text figures are set in type by the printer; they may be longer than those for plates and may include explanatory material. Each illustration is different, and individual judgment must be used to describe it.

A complete title and the figure number for each illustration are typed double-spaced on a separate page; the original is placed in the text as the page following the most important reference, and a copy is attached to the mill copy of the illustration (the copy of the original

that is submitted for technical or editorial review) for forwarding to technical reviewers. The figure number is also placed on the mill copy so that title can be matched with illustration should title and mill copy become separated. Any change in title must be made on the original and on the copy attached to the mill copy of the illustration before the report is submitted for Director's approval. This procedure assures that the title to be set in type, the title as cited in the body of the text, and the title placed on the plate by the illustrator are in agreement with the title given under the heading "Illustrations."

The following factors control the content and form of titles:

1. Identification of kind of illustration. In book reports the kind of illustration (map, photograph, diagram) should be indicated in the list of illustrations given in the front matter but generally is omitted in the figure caption itself. In separately published illustrations the kind of illustration must appear in the title. Although the map may contain secondary illustrative items such as cross sections, columnar sections, or diagrams, the map title ordinarily does not include mention of them but, if essential for giving maximum information, the presence of subsidiary or specialized data can be shown by such additions as "* * * and structure," "* * * and cross sections," "* * * showing sample localities." Subsidiary illustrations may require subtitles; these are not part of the overall figure title.
2. Geographic location. This information must be included in titles of separately published maps; quadrangle name, county or regional location, State or region must be shown. Geographic location is not necessary in titles of figures bound within a publication unless the figures portray only part of the entire area studied.
3. Qualifications. If special conditions affect the character of a map, qualifying adjectives such as "preliminary," "sketch," "generalized," "reconnaissance," "surficial," or "bedrock" may be used.
4. Multisheet maps and separate texts. If a map is printed in several sheets or includes a pamphlet text, a common title that applies to all sheets and (or) the pamphlet must appear on each. The individual sheets should also carry subtitles that identify the individual maps.

The illustration itself should not be confused either in caption or in text with the physical actualities it represents. Thus:

The west side of figure 2 is within 35 miles of the easternmost sedimentary rocks of the western Nevada Mesozoic province * * *.

A trace of the fault is exposed 5 miles north of figure 5.

The area shown in the left side of figure 2 is within 35 miles * * *

A trace of the fault is exposed 5 miles north of the area shown in figure 5.

Verbal scale, scale ratio, and magnification should not be given in a caption; a rake scale should be drawn on the figure or on a translucent overlay and registered to the photograph or photomicrograph for drafting by an illustrator, because the scale of the illustration may be changed in cartographic preparation. If the picture does not contain some object such as a hammer or a person whose size is easily recognizable in relation to the rest of the picture, the size of some recognizable object should be noted in the caption.

Map-unit symbols must be included in an "Explanation" or described in the caption; they must not be used in the text.

Use of Abbreviations

All words on illustrations and maps should be spelled out, with the following exceptions:

1. Geographic names. The noun (as mountain, mount, river, canyon, creek) may be abbreviated if, by using the abbreviation, clutter is reduced on the map. No period is used in the body of a map or linecut after an abbreviated word.
2. Units of measurement. Always abbreviate.
3. Geologic names. Nouns such as sandstone, conglomerate, and group may be abbreviated to fit into available space. See pages 142, 148.
4. Well names. Words such as "Company," "Corporation," and "Brothers" in well names may be abbreviated.

Abbreviations are treated at greater length beginning on page 93.

Credits, Acknowledgments, and Copyrights

In addition to any general acknowledgments in the text, credits for each individual illustration should be shown on the illustration or in the caption. The authorship of a map-series publication is shown on the map, usually directly under the title; however, authorship of a plate that is to be included with the text of a book publication is shown only in the geologic credit note, generally placed below the lower right corner of the map. Photographs taken by the text author are not credited to him; he is the author of the report. Photographs or other illustrations borrowed from others should, even if modified by the borrower, be acknowledged in the figure caption. (See also p. 44.)

Proprietary information, such as mine maps, drill-hole production, or sampling records, requires not only an acknowledgment but written permission from the owner, even if publication is to consist only of open filing.

If copyrighted material is to be reprinted, written permission must be obtained from the owner of the copyright and statement of such per-

mission must appear in the caption, either in the specific words requested by the owner or as "Reprinted from * * * and published with permission." The author retains the written permission. (See p. 34.) Though Government-published maps and texts are not subject to copyright, proper credit must be given for cited or republished work; it is also courteous to notify the original author that his work is being used.

Technical Review of Author Copy

The original drawing or compilation, as prepared by the author on scale-stable base, on cronaflex, or on paper, should not be submitted for technical or editorial review. Rather, a legible copy (Xerox, ozalid, or cronaflex) should be submitted. Such copy, usually referred to as "mill" copy, is the one that will be reviewed and approved for publication; it is also the copy that will be exclusively relied on by the editors and the illustrator for guidance in ordering and placing type for the final illustration that will be sent to the printer, although the illustrator will trace the original for placement and position of all linework and symbols. If there are discrepancies in linework between the original and the mill copy, cartographic preparation will be delayed while those matters are resolved. All linework corrections must be made on the original by the author; he must also indicate those corrections on the mill copy or note on the mill copy that the original is to be followed. Blurred, reduced, or otherwise illegible prints of illustrations or photographs make adequate review impossible and may well cause the reviewer to react negatively to the entire report. The time and expense of preparing final copy of illustrations for publication are directly dependent upon the legibility of the copy.

After technical review of illustrations, the author must study all questions and comments on the mill copy and make necessary changes on original illustrations. As with edited text, every query (?) by technical reviewer or map editor should be answered, either by appropriate change in the illustration or by making written reply to the query and striking the query mark. Negative one-word replies to a reviewer's comments are not acceptable. The reviewer has worked hard on the paper, and his questions deserve the author's consideration and answers. If the author wishes, he may supply a new mill copy, but he must transmit the reviewed copy, the reviewer's comments, and his reply to the comments with the new mill copy of the manuscript as it progresses through the review and approval routing.

Author, technical reviewer, and map editor should carefully check each illustration for possible errors of omission or commission. The following list, though incomplete, includes many of the points that should be checked conscientiously. The items apply particularly to review of copy for geologic maps and cross sections, but many are applicable to other types of illustrations as well.

1. Completeness:
   a. All units are labeled on map and cross sections and are in explanation.
   b. All geologic units in explanation are shown on map (except for subsurface units that may appear only in cross sections).
   c. All formal geographic names within the map area that are referred to in text are shown on map.
   d. Newly approved geographic names may be added to the base map only if the date of the domestic-names decision list on which it appeared is supplied. Unapproved or informal names are not shown on the map.
   e. Map symbols are not used in text. (See also p. 52, 141.)
2. Correctness:
   a. Plotting is accurate.
   b. Geographic and geologic names are spelled correctly in text and agree with spelling on map and explanation.
   c. Locations, directions, and dimensions (in metric or in both metric and English units; p. 193) as described in text and shown on maps and sections are in agreement.
   d. Geologic names and ages on map explanation agree with text.
   e. All special geologic symbols on the map appear in the explanation. The common map symbols printed on the back of map-series envelopes (fig. 1) are not shown in map explanations; the author and the map editor are responsible for deciding which symbols will be shown and which must be shown. (See also p. 62.)
   f. Dips as drawn in cross sections agree with projections of those on map.
   g. All features on map will be legible at intended publication scale.
3. Scale: Scale is shown graphically, in metric or in both metric and English units; ratio scale as 1:24,000, is optional but usually not shown on figures or maps which may later be enlarged or reduced.
4. Topographic contour interval and datum: Shown beneath title.
5. Caption: Title is succinct but definitive. For a plate or a series map, "map," "cross section," or other suitable descriptive term is included. "Geology of the Blank Quadrangle" is not acceptable, but "Geologic map of the Blank Quadrangle" is.
6. Authorship: Shown beneath the caption in a series map; shown in the geologic credit if in a book publication.
7. Geologic credit: Authors, compilers, and contributors are named; dates of mapping are given. A source index may be substituted.
8. Base credit: Source, date, and map projection, if other than standard topographic map, are given.

9. Cooperative note: Sponsor or cooperating organizations are shown at top of map in map series and in map plates for foreign areas. The wording to be used if the cooperating organization expresses no preference is "Prepared in cooperation with * * *."
10. Marginalia:
    a. True and magnetic north and numerical declination are shown; if standard base map is used, illustrators will add these. The magnetic north arrow and declinations are unnecessary on page-size figures; they also should not be shown on aeromagnetic map plates, for they can be a source of confusion depending on whether the declination is that of the date of the base, the date of the data collection, or the date of the publication of the map. True north arrow is unnecessary on page-size figures if latitude and longitude ticks and values are shown.
    b. Latitude, longitude, townships, ranges, geographic reference points or grids, positions of cross sections are all shown by ticks marks, which are labeled.
    c. Vertical scale and exaggeration ("Vertical exaggeration ×2") appear on sections.
11. "Check Sheet for Illustrations and Maps": Check sheet is complete, especially as to notes for draftsman regarding colors and important map units.

Transmittal for Approval and Preparation

Mill copies of illustrations must be transmitted with the manuscript text but in a separate package at the back of the text; they should not be inserted in the text. The author should hold all original material (including line drawings and photographic negatives) until requested for use in final preparation, after Director's approval.

A list of illustrations (at one time called short list) must also be included, even though it may not be published. The list should show, for each illustration, the type (map, diagram, photograph, or other), a unique short title that is easily related to the illustration, and the manuscript page number where the illustration is most prominently described (the principal reference). The list should be typed in order of principal reference in the text, which may not be in numerical order of the first mention. The original of the list is inserted in the manuscript after the table of contents; a copy is placed in the illustrations package.

Descriptive caption material for Survey text publications should be typed on a separate page for each illustration and inserted in the text as the page following that on which the principal reference appears. A locating reference to the illustration should be placed in the text on the line after the principal reference, as:

FIGURE Z.—Near here

For journals, see specific instructions that can be obtained from the publisher.

Except for photographic plates of fossils, the author should designate all illustrations as figures. All figures should be numbered consecutively as the manuscript is prepared. Once a number is applied it must not be changed except to correct an obvious error such as a duplicate. The editor will separate plates from figures and will renumber them when the manuscript is made ready for final transmittal to the printer. Any attempt to change numbering during the evolution of a manuscript will be wasted time and will perhaps cause errors. If the final text as transmitted by the author requires rearrangement of the original order of the illustrations, this fact will be shown by the page numbering and by the order of numbers in the short list. Deletions or combinations of numbered illustrations will be shown the same way; the number of the deleted illustration will be listed, but shown as "Deleted" or "Combined with figure 7." A copy of the text caption (on a page-size sheet of paper) and a completed "Check Sheet for Illustrations and Maps" must be attached to the mill copy of each illustration. Special instructions as to placement of figures in the text should be noted on the caption sheet in the text, as, "Text Editor: Please print on page facing figure 7" or "To be printed on same page as figure 7."

Figure numbers should appear on the illustrations themselves, not on attached slips. If copy for the illustration consists of more than one piece, as a base map and an overlay sheet for geologic contacts or as three sections in three pieces, that fact should be shown on each piece, as "Figure 15, part 2 of 3 parts."

REVIEW OF PUBLICATION DRAFTING

Transmittal routing procedures of drafted Survey illustrations vary from office to office, but before the report goes to the printer, the author will receive his original illustrations, his mill copies, and check prints of the drafted art. This material usually will accompany the edited text if the illustrations are part of a book report. ("Check prints" are washcoat-color prints or black-and-white copies of figures and photographs; "proofs" are prints from the printing press and are rarely made.) The check prints ordinarily provide the last opportunity for the author to make corrections. It is the author's responsibility to check those prints carefully for placement of lines and type, symbols, explanation, spelling, color or patterns, and titles. Any changes or corrections should be clearly marked on the check print by using a straightedge to draw a line to the margin from the item to be corrected and noting the correction in the margin, so that the illustrator will understand the change. Any corrections or queries that have been placed

on the check prints by the illustrator or editor should also be reviewed by the author and marked to show his agreement or disagreement.

At check-print stage, significant changes not on the approved mill copy must be justified to the map editor at the time the check print is returned. The mill copy and originals must not be updated or otherwise altered at this time. All changes the author requests may not be granted. Some requests may be deleted as being unnecessary or even incorrect. The map editor will accept essential changes, and those desirable changes that can be made quickly, easily, and inexpensively.

The author must date and initial each check print; however, if the final drafted illustration is unacceptable and the author feels he must see a new, corrected check print, he should so state and should not initial that print. The author must return all the check prints, the originals, and the mill copy.

After approved changes are made in text and illustrations by the Publications Division, the manuscript and illustrations are readied for transmittal to the printer.

Disposition of Original Illustrations and Photographs

Author's original illustrations and mill copy are returned after the final drafted material is transmitted to the printer. The author should retain that material at least until the report is published. The copy that the printer uses for publication will be returned to the author if he requests it; it may be returned or discarded if he does not ask for it. Negatives for color-printing plates are now retained in the Federal Archives for reprinting. If negatives are not available, a paper print may be scanned electronically to make color negatives for reprinting. If a report is reprinted, black-and-white figures and plates are copied from the publication itself; black-and-white photographs will be prepared from the negatives on file in the Survey's Photographic Library.

All photographs, negatives, and slides should be deposited in the Survey's Photographic Library (U.S. Geological Survey, Mail Stop 914, Box 25046, Denver Federal Center, Denver, CO 80225) at the completion of each Survey project. Negatives for pictures that are used in published reports are sent to the Photographic Library by the Publications Division after preparation of copy for the printer. The collection is consulted by Survey authors and other authors who need appropriate pictures for textbooks and scientific articles.

Kinds of Illustrations and Their Special Requirements

Geologic, geophysical, and hydrologic maps

Geologic, geophysical, and hydrologic maps are major illustrations and offer special problems. Planning for compilation and publication

scale is discussed on pages 50–51. In making a decision on the design of map for either map-series or book publication, the author is in reality determining its continuing availability to future users. Maps in numbered series generally are reprinted as supplies are exhausted; maps in book series are allowed to go out of print and reprinting is rarely considered. It is advantageous, therefore, for maps to be printed in one of the map series and referred to in a book publication. If necessary to the understanding of the book publication, a small-scale generalized map may be included as a substitute for a separately published large-scale map.

The author should compile his map data directly on a stable base. Compilation on an overlay provides too much chance for slippage and consequent poor registration between the overlay sheet and the base. He should use black ink, for colored inks may not print well in black-and-white direct prints nor do they photograph well; colored inks must not be used for final compilation. Scribing of the map may be substituted for ink; however, scribing requires that the base map be printed on scribe-coat material and the map compiled thereon. If a map is compiled on scribe coat, then photographic combination of the scribed lines on a screened or green base for review copy is required. The map editor can arrange for the preparation of this combination print. The author completes the map by adding geologic formation and structure symbols in ink.

All contacts should be drawn as solid lines. In special situations, dashed or dotted lines may be shown on final maps, but a special line guide is then required (colored pencil on a black-and-white print showing exactly which portions are to be dashed and which are to be dotted by the illustrator). If most contacts on a geologic map are approximately located, all should be shown as solid lines and explained, "Contact—Approximately located." The original must not be colored; a suitable paper or plastic copy should be colored as a check copy and as a mill-copy guide to the illustrator.

Explanations

The explanation is an essential part of the geologic illustration, for without it the map, cross section, or diagram can be understood only with great difficulty. It is the first part of an illustration to be studied and the part that is most frequently consulted by the user. The explanation must include all information necessary to the understanding of the figure, which must stand alone without reference to the text or to another figure. However, nothing should be described in the explanation that is readily apparent on the map or its subsidiary cross sections or that is described in the text. If space within the figure is available, a unique feature can be labeled directly on the map and its symbol need not be listed in the explanation.

Two types of map explanations are used in publications of the Geological Survey, the short and the expanded. Both types usually consist of a "Correlation of Map Units," a "Description of Map Units," and a listing of the line conventions and geologic symbols used on the map. As "short" and "expanded" imply, the two types differ only in the stratigraphic and lithologic detail placed in the "Description of Map Units."

Special problems may arise in the form and layout of explanations for maps involving large areas. Recent publications of the Survey reflect experimentation in format of explanations, and the reader is referred to the maps by U.S. Geological Survey (1972), Haley (1976), and Tweto (1976).

The treatment of stratigraphic symbols and the arrangement and format of map-unit boxes in the "Explanations for Geologic Maps" are given on pages 138–142 and figure 5. The "Description of Map Units" must include the rock-stratigraphic names of the units and the systems to which the units are assigned; it may also include information such as lithologies, grain size, color, bedding characteristics, thickness, porosity, permeability, fracture characteristics, phenocryst or fossil content, remanent magnetization, correlation with other units, potassium-argon or other age determinations, and source of specific information (citation). Limiting factors for the length and detail of such explanatory material are the size of the map and the number of map units. Where space is available, an expanded "Description of Map Units" giving stratigraphic detail is desirable.

The short "Description of Map Units" includes the names of the groups, formations, or members but either no descriptive material or description limited to the major lithology. Short explanations may depend on a book text or a graphic columnar section to flesh out the bones with lithologic details.

Stratigraphic details should be limited to data from within the map area; however, limited correlations with formations in the surrounding region may be included. Citations ("references") may be included in descriptions (use the form shown on p. 79–81). All descriptions should use telegraphic style. All nonessential articles ("a," "an," "the") should be deleted; complete sentences are unnecessary; participial phrases are encouraged; and, instead of conjunctions and other superfluous words, semicolons or periods should be used to separate ideas. The description may be "paragraphed." Periods are omitted at the end of each individual entry or paragraph.

The treatment of rock-stratigraphic units and stratigraphic symbols is covered in detail in pages 138–142.

The order of discussion of the lithology may differ from map to map; it should be consistent within a given "Description of Map Units" (fig. 5). Inverted sentence structure (see p. 144) is unnecessary, because the major lithology, if any, is given in the rock-stratigraphic name; if the formation consists of a mixture of lithologies, no one being dominant,

it is better to list them all in normal word order, as "Sandy green shale and silty light-gray sandstone * * *." Features that characterize a unit, such as color, permeability, or gradations in grain size, also modify the lithologic term; other information (magnetization, fossil or phenocryst content, age, and so on) follows. The order in which these subsidiary features are listed is immaterial, but usage should be consistent throughout the description. The author should consult recently published maps as a guide to preparing a "Description of Map Units."

Other parts of this book which have specific bearing on content and form of the "Description of Map Units" follow:

Geologic map symbols

Geologic map symbols other than stratigraphic map symbols (see p. 138–142) are placed below the map-unit boxes. Symbols for outcrops, contacts, faults, folds, planar features, bedding, cleavage, joints, geophysical isopleths, ore and rock alterations, mine development, and oil, gas, and water wells are available from the map editor. Common map symbols given in figure 1 need not be included in the explanation; they are generally accepted and also are printed on the backs of recently issued map-series envelopes. Rarely, with the approval of the map editor, an author may devise special map symbols. Special map symbols, symbols used in a different way, or symbols with great importance to an illustration should be given in the explanation. The order of listing of symbols as generally shown is given in figure 2, but the order may be altered for emphasis. If space is available, a unique symbol may be identified directly on the map; it is not then necessary to describe it in the explanation.

Cross sections

Geologic cross sections represent the author's interpretation of the structure and stratigraphy shown on the geologic map, made graphic so that the map and structure are more easily understood. The principal control is provided by the surface geologic map, by subsurface or mine maps, and by drill-hole data on or near the line of section. Cross

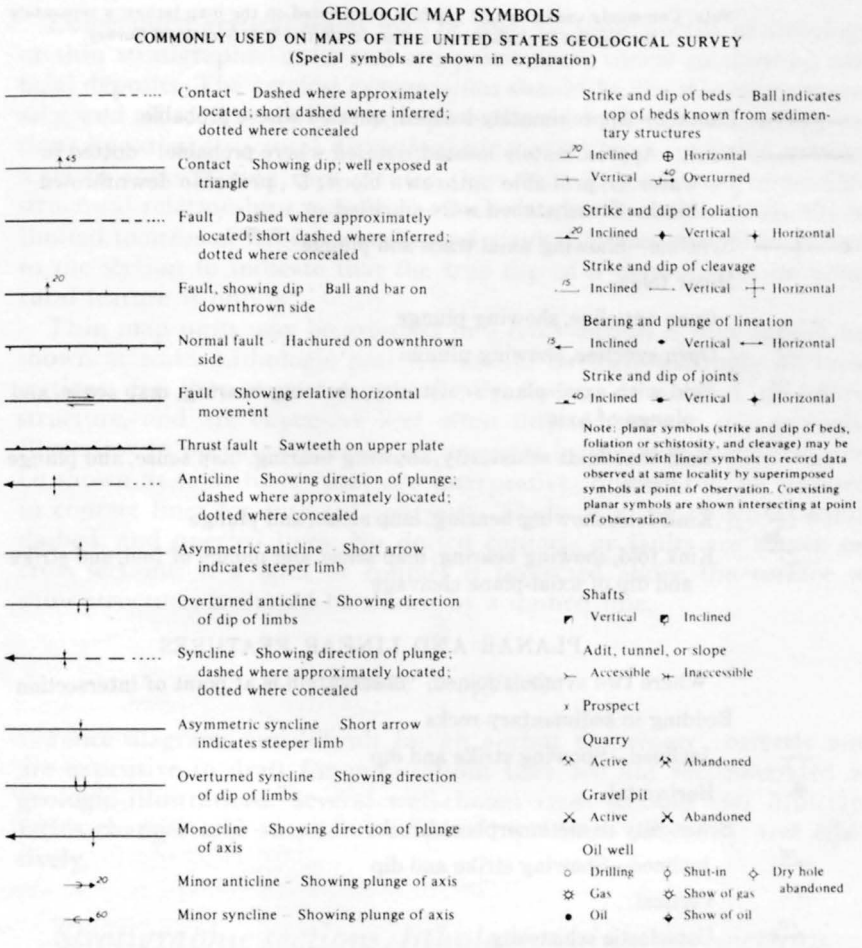


FIGURE 1.—Commonly used geologic map symbols. Reprinted from back of U.S. Geological Survey map-series envelope.

sections should be drawn through areas where geologic relationships at depth have economic or scientific importance and where sufficient data are available. The number of sections should be no greater than necessary to demonstrate the inferred geologic relationships. They should show significant facts that are not demonstrated elsewhere and that are difficult or impossible to describe in the text.

Structural data are best shown by cross sections oriented perpendicular to the prevailing structural trends. The sections need not necessarily extend across the entire map, particularly if little of structural importance is shown at one end or the other. They are usually oriented as if the observer were to the south, or in the southeast corner of the map area, looking north or northwestward. If a series of sections is drawn to illustrate through-going geologic structures common to all

Note: Commonly used geologic symbols are printed on the map jacket; a separately printed list is available on request from the U.S. Geological Survey.

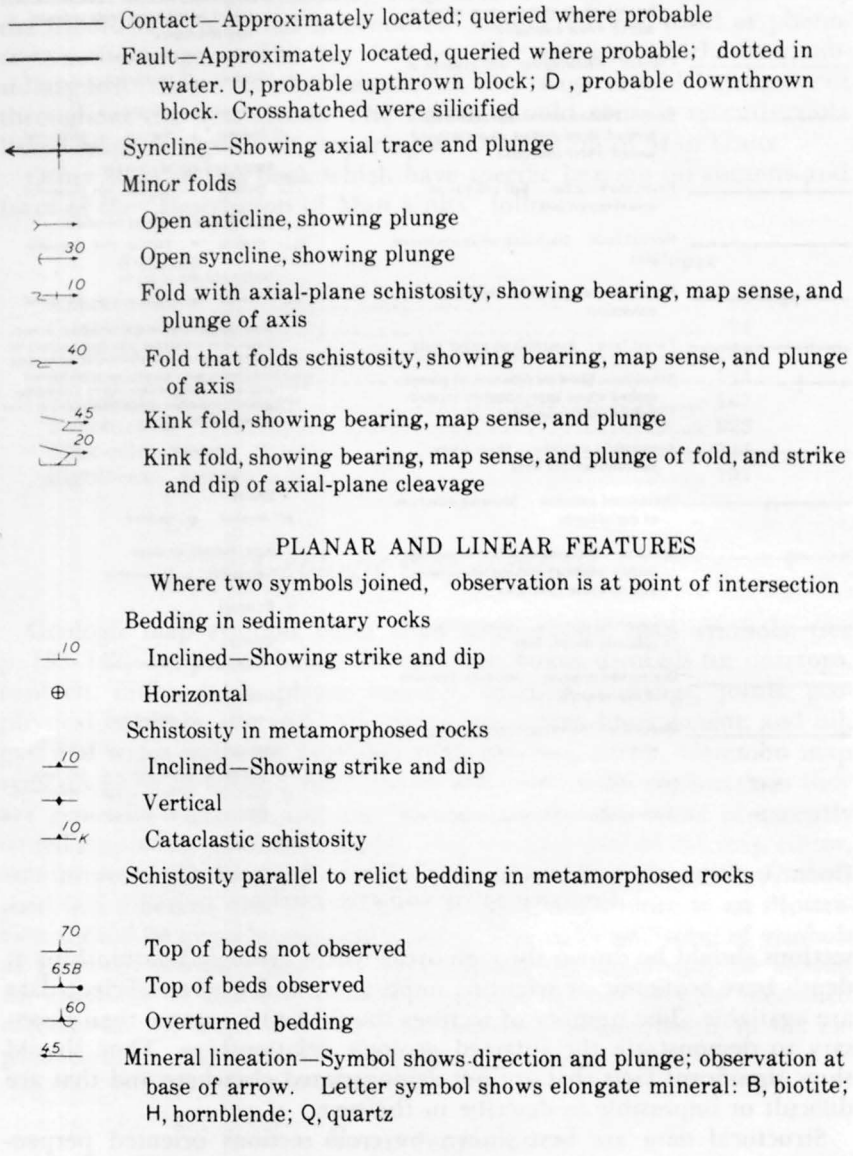


FIGURE 2.—Sample explanation of some geologic map symbols. Abstracted from Pepper (1977).

sections and if the strikes of the through-going structures are such that a common orientation according to the rule is not possible, the sections are arranged so that the geologic structures maintain the same relationship to each other.

Exaggerated vertical scales may be used to show details of lithology or thin stratigraphic units and are particularly useful in showing surficial deposits. The vertical exaggeration should be the minimum necessary, and all sections on the same plate should have the same exaggeration. Apparent structural distortions are caused by exaggerated vertical scale in rocks having dips greater than 10°; illogical and impossible structural relationships may result. Such exaggerated sections should be limited to areas of flat-lying rocks, and a suitable note should be added to the section to indicate that the true dip of a depositional or structural feature is only x°.

Thin map units may be grouped in a cross section if they cannot be shown at scale. Lithologic patterns should be used sparingly on cross sections, for they must be individually drafted or scribed to follow structure, and are expensive and often difficult for the non-geologist illustrator to prepare correctly. All contacts in the cross section should be shown as solid lines (they are interpretive; queries can be inserted in contact lines for inferred contacts). Faults may be shown as solid, dashed, and queried lines. No dotted contacts or faults are shown on cross sections; if a fault or contact is projected above the surface to show structure, it should be shown by a dashed line.

Fence diagrams

Fence diagrams are difficult for an author to prepare correctly and are expensive to draft for publication; they are not recommended as geologic illustrations. Several well-chosen cross sections can illustrate facies changes and structural relationships more efficiently and effectively.

Stratigraphic sections, lithologic columnar sections, and well logs

Because the Publications Division illustrators may have difficulty interpreting correctly the fine lithologic detail of columnar sections and well logs, the author is urged to keep in mind publication scale and usable size of the printed illustration and to draft his material at publication scale or for not more than 20 percent reduction so that original linework can be used without redrafting; then the illustrator will need only to add type for column headings, explanation, and title. The author should consult with the map editor on line weights and special symbols. Lithologic symbols used in a graphic column must be explained separately unless the description of each unit is printed beside the column and is clear.

The vertical scale chosen for publication should be measurable directly with a metric scale. Final published width of columns should be not less than 1 nor more than 2 cm.

Special types of logs are used to show engineering and geophysical characteristics of rocks measured in exploratory drill holes. Any type of continuous log, such as electric, radioactivity, or temperature, should be drafted by the author, or under his immediate supervision, with the expectation that it will be photographed and used for final publication copy. Only the author knows what degree of generalization of a log is acceptable.

Color is unnecessary for illustration of graphic logs and sections. Black-and-white patterns and distinctive contrasting line weights are sufficient.

Index maps

Most book reports and journal articles should include at least one index map which identifies the area of the report within the State or other geographic region and shows major geographic locations referred to in the report. If the report includes no major map of the specific area, a second map showing all local geographic and structural features mentioned may be necessary. An index map must include latitude and longitude (or township and range and a north arrow if latitude-longitude is not available), a rake scale, a neat line, at least minimal drainage, and cultural features such as towns. County lines, roads, and minimal topography may be included on the second map. A township and range grid alone is undesirable; the reader is better able to relate geographic position to towns, drainage, and roads. If several counties or States are included, these names should be included on the figure. The report area should be designated by pattern.

Map-series publications usually include a small outline map of the State that shows the map area in black. Additional regional index maps may also be included to show sources of information, credits for areas of mapping, and published maps of adjacent areas.

If only latitude and longitude coordinates and area outlines (but no geographic or cultural data) are given, the figure is not an "index map" but an "index."

Photographs

Well-chosen photographs, each adequately described, essential to the reader's understanding of the text, and easily reproducible, are some of the best and least expensive illustrations to prepare and print. Authors should not submit more photographs than are really necessary, in the mistaken belief that a certain proportion is arbitrarily rejected. This practice wastes everyone's time and may be self-defeating because reviewer and author may not agree on the "essential" pictures.

Glossy prints should be submitted with mill copy and copies of text that go for simultaneous review. Xerox copies of photographs are not acceptable for review or for Director's approval. Negatives should be held by the author with other original illustrations until requested by Publications Division. It is important that review prints be submitted at close to final publication size so that the editors can verify that the photographs show what they purport to show.

If the author wishes to publish a photograph for which a negative is not available, especially if he has only one print of the picture, he should have made a 4- by 5-inch copy negative of publication quality. If the author wishes to publish a black-and-white photograph from a color slide or color print, a black-and-white 4- by 5-inch negative and a print at near publication size should be prepared for review and publication.

The mill copy for a color photograph should be a color print about the size at which it is to be published and should have the color rendition as desired for publication; the printer will use the mill copy as a guide to color reproduction. The original slide or color negative should be furnished for the printer's use and marked "To be returned to USGS Photographic Library."

If it is desirable to print a long narrow picture in a Professional Paper, as a panoramic view made of three or four photographs, it is better to print the photograph across two pages than to print it as a side-title figure. If as much as one-fourth inch on each of the two edges can be cropped without loss to the picture, the printer can bleed the photograph to the edges of the page. Such a photograph on a Bulletin page can be as much as 25 percent larger than the conventional-size Bulletin-page photograph. Bled photographs are exceptional, however, and should not be used indiscriminately.

Authors should generally not attempt to mount their photographs, panoramic or other, for the printer. Instructions for preparation of photographs follow.

1. Submit glossy print at publication size or indicate publication size by crop lines on overlay. Do not trim along crop lines but submit print of complete negative.
2. Request 200-line screen only for fossil plates and where fine detail is essential.
3. Do not write on emulsion side or back of photographs and do not use paper clips. Scale should be drawn outside image area or on overlay.
4. Use registered overlay to show line and symbol placement. Never draw on photographic prints.
5. Do not mount with glue, tape, or permanent attaching materials.
6. Do not place any kind of tape over image area.
7. Register all overlays by corner ticks or other marks; indicate top if not obvious.

8. Rotate photomicrographs 90° if necessary to fit column width; photomicrographs should not be reduced.

Instruction to the photographer concerning cropping, dodging to bring out detail, or other treatment may be placed on the mill copy, on a translucent overlay of the mill copy, or on the back of a "Check Sheet for Photographs."

Captions for photographs must note the geologic features shown. "View of Heart Mountain," for example, is insufficient. The location of the area, the direction in which the photograph was taken, and the date of photography, if pertinent to the appearance of the subject, should be a part of the caption. The caption should also contain a reference to the scale of the photograph and an explanation of any symbols shown on the overlay. Manmade structures such as head frames, except those incidental to geologic subjects, are not acceptable as illustrations.

Photographs are poorly reproduced on map presses, and map-series reports ordinarily do not contain photographs. Strong justification is required for printing photographs in map series.

Sketches from photographs

Sometimes the nature or quality of photographs is such that the geologic relationships are not obvious; in addition a printed overlay showing those relationships and the names of geographic features may obscure the geology. Line drawings (sketches) prepared from the photographs can better portray the geologic information than a poor-quality photograph; a simple sketch printed beneath the photograph, or instead of the photograph, and showing the geographic and geologic features can explain the relations better than words. The author can prepare a rough sketch on a translucent overlay and submit it and the original photograph to the illustrator as a guide for making the sketch.

Fossil plates

Fossil plates are usually prepared by the author, who should consult recent publications for layout and style of captions. Technical advice for the preparation and mounting of the parts of the plate can be obtained from an illustrator.

Aerial photographs and shaded-relief maps

Except for the need to preserve fine detail, single aerial photographs present no special preparation or reproduction problems. Aerial photo-

graphs that are to appear as stereopairs, however, do present problems and are permitted only with strong justification. Their effectiveness depends on uniformity of tone for both photographs, as well as exact placement for stereoviewing. Moreover, few readers can see in stereo without special equipment. Stereopairs should be submitted at publication size; the author should mount the stereopair himself or work closely with the illustrator in mounting it.

For some aerial photographs and shaded-relief maps, the general rule or orientation with north at the top of a page may need to be modified. For example, the reader may be distracted by shadows that appear to invert the topography and cause him to "see" streams instead of ridges or domes instead of craters. To avoid such erroneous visual perceptions, the picture or map can be mounted upside-down so that relief is most easily perceived by the average reader. A north arrow and scale should always be added.

Inexpensive shaded-relief maps for use as index maps can be created by using special lighting to photograph the back of plastic raised-relief maps. A description of the method is given by Stacy (1962, p. D165). The author should prepare a translucent overlay registered to the photograph to show geographic and geologic features to be added by the illustrator.

The source, identification number, and date of all aerial photographs or other remotely sensed images, such as Landsat multispectral images, should be a part of the caption.

Frontispieces

Rarely, a book publication contains a frontispiece, which usually illustrates the general subject of the report although it may be an outstanding picture of more specific nature. If justified, color may be approved (Ratté and Steven, 1967). It may be a panorama of the area (Love and Keefer, 1975), or a sketch or drawing.

Graphs and diagrams

Many kinds of graphs can be prepared; each has its specific purpose (fig. 3). Commonly used scales include arithmetic, logarithmic, semilogarithmic, and probability, shown by a grid which may be either a complete network of lines across the diagram or merely ticks along the vertical and horizontal axes. If extension of the grid across the graph is important to the reader, the graph or diagram should be outlined and ticked on all four sides. The grid should be extended to include all data shown on the graph.

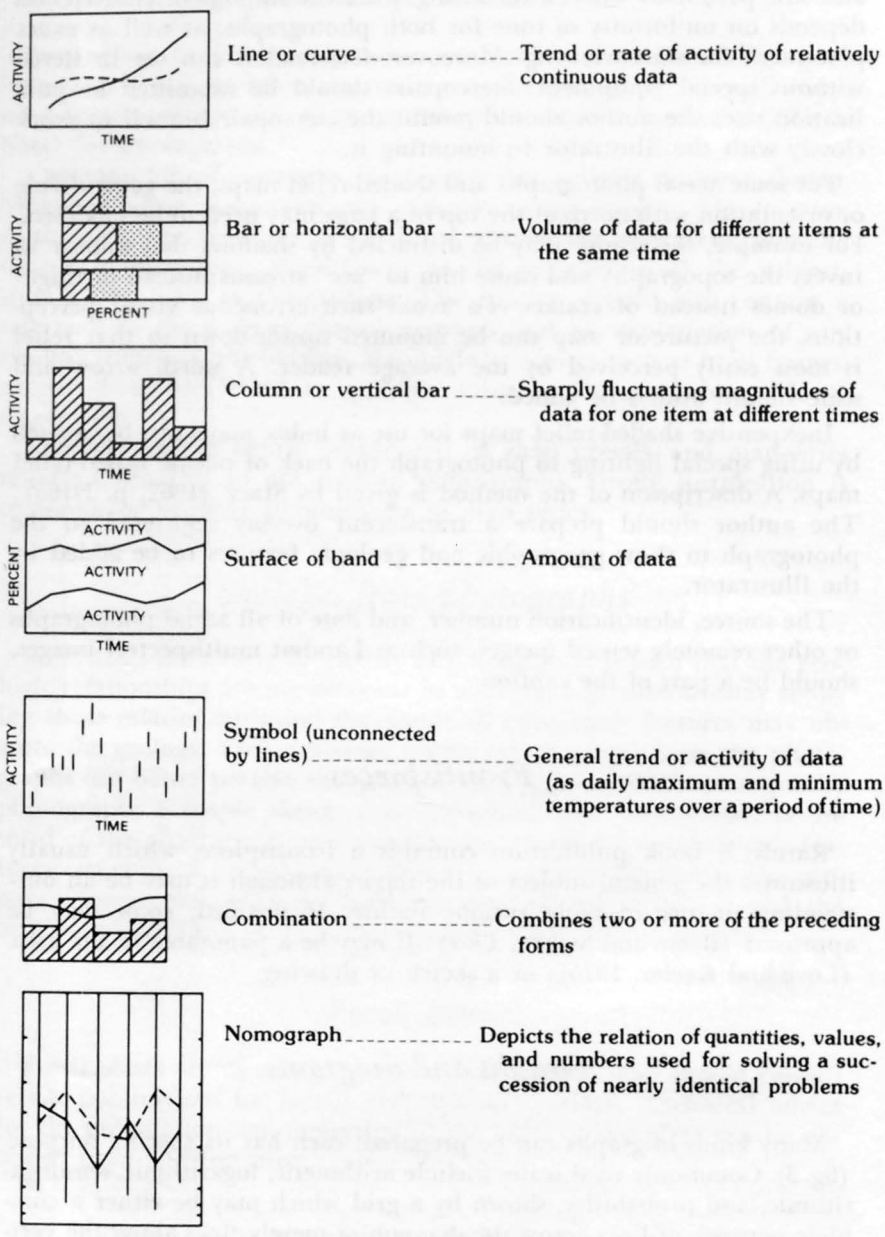


FIGURE 3.—Various types of graphs and their nature.

Scales are generally labeled only along the left and bottom axes. Scale numbers should increase from bottom to top and from left to

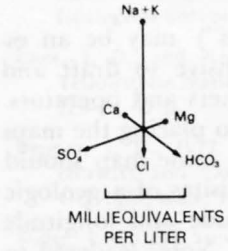
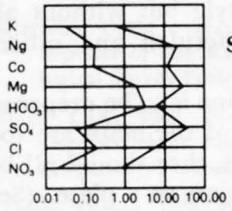
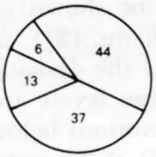
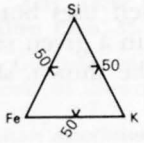
TYPE OF GRAPH	EMPHASIS
 Radiating vectors diagram	Shows results of analyses
 Semilog concentration graph	Shows distribution of selected groups of data
 Circular (pie) diagram	Subdivision of a whole by means of a circle which is divided into percentages
 Triangular diagram	Shows composition in terms of relative amounts of three components
 Schmidt equal area projection	Shows azimuths measured clockwise from north and about a point directly beneath the observer (if grid is deleted, center point is shown by a "+" and north is ticked)

FIGURE 3.—Continued

right. Captions for axes are all in capital letters; they should be complete, and include the unit of measurement as "_____, IN PERCENT." All symbols used on the graph or diagram must be explained either in an "Explanation" or in the figure caption.

Mine maps

Detailed mine maps (not "plans" or "plan maps") may be an essential part of a report. They are, however, expensive to draft and many times are of interest only to specific mine owners and operators. If of limited interest, consideration should be given to placing the maps in open file. Regardless of method of publication, a mine map should have a complete explanation and all the other requisites of a geologic map (north arrow, scale, location in terms of latitude and longitude ticks or, at minimum, section, township, and range). Notes leadered to points of pertinent observations may take the place of a lengthy explanation; such notes should be in telegraphic style but without abbreviations except for units of measurement (Sheridan and others, 1967, pls. 2–7).

If a series of maps of various levels of the same mine is to be prepared, the maps should all be at the same scale. If some of the maps are too large to be printed on a single page or facing pages, they should all be grouped in a logical and easily understandable fashion on a plate. (See Hawley, 1969, pl. 4.) A second color may be used to depict ore or other mineralization and geology if such features cannot be shown clearly by black-and-white patterns (Bergendahl and Koschmann, 1971, pl. 2).

Mine levels may be designated in two ways: (a) If the designations merely constitute a numbering system in which mine levels are not separated by precise intervals or located at precise elevations below the surface or other datum, "100 level" is appropriate; (b) if the company designation in addition represents surveyed or precise elevation, "100-foot level" is appropriate. If the mining company itself uses both systems, either is acceptable but only one should be used in a given report. Names for levels or other workings, if they need to be shown, should be those applied by the mine operator.

Engineering drawings

Circuit diagrams, working drawings for construction of laboratory apparatus, and patent drawings (which are usually exploded drawings of the working model) are sometimes required in a specific type of geologic report. The advice of a professional engineering draftsman should be sought before attempting such a drawing.

References

Bergendahl, M. H., and Koschmann, A. H., 1971, Ore deposits of the Kokomo-Tenmile district, Colorado: U.S. Geological Survey Professional Paper 652, 53 p.

Haley, B. R., 1976, Geologic map of Arkansas: U.S. Geological Survey, scale 1:500,000.

Hawley, C. C., 1969, Geology and beryllium deposits of the Lake George (or Badger Flats) beryllium area, Park and Jefferson Counties, Colorado: U.S. Geological Survey Professional Paper 608–A, 44 p.

Love, J. D., and Keefer, W. R., 1975, Geology of sedimentary rocks in southern Yellowstone National Park, Wyoming: U.S. Geological Survey Professional Paper 729–D, 60 p.

Pepper, J. D., 1977, Bedrock geologic map of the Hampden Quadrangle, Massachusetts and Connecticut: U.S. Geological Survey Geologic Quadrangle Map GQ–1368, scale, 1:24,000.

Ratté, J. C., and Steven, T. A., 1967, Ash flows and related volcanic rocks associated with the Creede Caldera, San Juan Mountains, Colorado: U.S. Geological Survey Professional Paper 524–H, 58 p.

Sheridan, D. M., Maxwell, C. H., and Albee, A. L., 1967, Geology and uranium deposits of the Ralston Buttes district, Jefferson County, Colorado: U.S. Geological Survey Professional Paper 520, 121 p.

Stacy, J. R., 1962, Shortcut method for the preparation of shaded-relief illustrations, *in* Short Papers in Geology, Hydrology, and Topography: U.S. Geological Survey Professional Paper 450–D, p. D164–D165.

Tweto, Ogden, 1976, Preliminary geologic map of Colorado: U.S. Geological Survey Miscellaneous Field Studies Map MF–788, scale 1:500,000.

U.S. Geological Survey, 1972, Surficial geologic map of Yellowstone National Park: U.S. Geological Survey Miscellaneous Geologic Investigations Map I–710, scale 1:125,000.

Additional Reading

Allen, Arly, 1976, Steps toward better scientific illustrations: Lawrence, KS 66044, Allen Press, 33 p.

Guidance in the preparation of figures by the person without access to professional illustrators.

American Association of Petroleum Geologists, 1970, AAPG slide manual: 33 p.

A book on how to prepare legible projection slides.

Blackadar, R. G., Dumych, H., and Griffin, P. J., 1975, Guide to authors—A guide for the preparation of geological maps and reports: Geological Survey of Canada Miscellaneous Rept. 16, 199 p.

The STA of the Geological Survey of Canada.

Keates, J. S., 1973, Cartographic design and production: New York, John Wiley, 235 p.

A guide for readers interested in learning about printing processes as well as cartographic methods.

Ridgeway, J. L., 1920, Preparation of illustrations for reports of the United States Geological Survey * * *: U.S. Geological Survey, 101 p.

"* * * with brief descriptions of processes of reproduction (title page)." For many years "Ridgeway" was the standard guide for preparation of illustrations for Survey reports. "Ridgeway" has long been out of print, and much of its information is out-dated, particularly its descriptions of drafting and reproduction techniques, but it is still of historical interest.

MATTERS OF STYLE

REFERENCES

Most scientific reports contain references to other researchers. If the report contains only a few references, the complete citations may be given in footnotes or in parentheses in the text. The more common Survey practice is to give the author, date, and page (s) of reference in text in parentheses and then to list complete citation at the end of the report. Survey style tries to avoid any need for "idem," "op. cit.," or "ibid."

Footnote references are indicated in the text by a "shelf" (__/). The footnote is typed just below the line in which the reference mark appears and is set off by rules above and below. The "shelf" in the text is placed just after the name of the author cited or, if the name is in the possessive form, after the noun following it ("Gilbert's theory __/"). Footnotes should not be numbered by the author; the numbering will be done by the editor after all eliminations and additions have been made, just before the manuscript goes to the printer.

Reference in text

If the reference pertains to only one text sentence, the identifying information is usually given in parentheses at the end of the sentence unless the reference is not pertinent to some part of the sentence, as in "Anchorage was severely damaged by landslides, ground subsidence, and fissures during the 1964 earthquake (Hansen and others, 1966, p. 73), but little effect of this damage is now visible." If the author's name naturally falls in the sentence, only the date and the page reference are included within parentheses, as in "Schaller (1911, p. 49) reported that the type specimen of this material contained 3.21 percent Li_2O." If the reference pertains to more than one preceding sentence it may be identified in a separate sentence, as " (See Hansen and others, 1966, p. 73.)." All text references should indicate the appropriate page and (or) illustration numbers unless the reference is to an alphabetical compendium such as a dictionary or glossary. It is an inconsiderate author who forces his readers to search the citation index for his reference, with no guarantee of success when they search.

References to several publications of an author in the same year are distinguished by adding a, b, c . . . after the year, in chronological order

of publication: "(Campbell, 1970b, p. 205)." If a paper has two authors, the material within the parentheses should have both authors' names, as in "Ephesite contains as much as 3.80 percent Li_2O (Schaller and Carron, 1952, p. 301)." If it has three or more authors and if there is only one reference that can be so cited, the reference may be to the first-named author "and others," as in "(Palache and others, 1951, p. 825)," instead of "(Palache, Berman, and Frondel, 1951, p. 825)."

Multiple text references are in chronological-alphabetical, inverse-recency order:

(Smith, 1962, p. 67; Jones, 1970, p. 406–410)
(Smith, 1962, p. 84; 1971, p. 98–104; Jones, 1970, p. 612)
(Smith, A. B., 1962, p. 3–42; Smith, A. J., 1962, p. 104; Jones, 1970, p. 91–98)

References should be identifiable and, in general, available for reference. Perhaps "(V. E. McKelvey, oral commun., *or* written commun., 1974)" is the best that can be done for data and opinions given orally or by personal correspondence, but for other correspondence, file maps and other data, unpublished theses, administrative reports, and perhaps some manuscripts in preparation, the reader may feel entitled to more tangible information. An unpublished thesis might be identified in text, for instance, as "(J. P. College, 1968, 'Well on Fire!': New Orleans, La., Tulane University, unpublished thesis, p. 10–51)." If the same thesis is referred to more than once, it might be identified by listing in "References" rather than in text. The text citation would then be "(College, 1968, p. 10–51)." If unpublished data are cited, the compiler and (or) place where the data are on file should be given. The dates of all types of unpublished data should be included—they may be vital factors in the value of the data. An unpublished report could be identified in text or "References" by appropriate variation of the following:

Harris, Leo, 1964, Maintenance foreman's report on earthquake damage: Unpublished data on file in Valdez office of Alaska Department of Highways.

Open-file reports of the Survey and other organizations may be cited and included in "References" if information is given as to where they are available for inspection or distribution (see example 17).

In general, the titles of books, articles, and reports that are quoted in text are enclosed in quotation marks and their first word and all important words are capitalized: "Dictionary of Alaska Place Names," "Standard Handbook of Prepositions, Conjunctions, Relative Pronouns, and Adverbs." This practice applies if the complete formal title is quoted. For references that are to be used many times in text, a shortened informal term may be identified and used, thus "Webster's Third New International Dictionary of the English Language" (WNI 3), then, after first usage, "WNI 3" (used without quotation marks); "U.S. Government Printing Office Style Manual" (GPO SM, *or* GPO style

manual), then, after first usage, "GPO SM" or "GPO style manual" (used without quotation marks).

See "Choice of Tense" (p. 211) for discussion of verb tense to be used for references.

Reference list

The style detailed below for listing references is applicable for most Survey textual and map reports. Style for listing items in special-purpose bibliographies and in other special reports may vary.

In the reference list, items appear by author in alphabetical-chronological order; all of a single author's works are listed before those he has co-authored. Preferred multiple-author precedence is illustrated in examples 3, 4, 25, 36. Repetition of a name or group of names is avoided by use of a dash (see examples 27, 28). The dash indicates that the name(s) of the author(s) of the reference is exactly the same as the omitted name(s). That is, if Jones, A. J., is the author of the reference immediately preceding a reference by A. J. Jones and B. M. Smith, a dash would not be used. The dash is written next to the date, with no space or punctuation between.

The heading "References Cited" or "References" is used if all the citations listed are referred to in the text. "Selected Bibliography" or "Selected References" is used if the list is more extensive, "Bibliography" if it is exhaustive.

The elements of the citation should be given in the order shown below. An initial "The" is given in the title of a book or article but is usually omitted in all other elements of the reference list.

1. Author(s), editor(s), or compiler(s), as applicable.
   a. If author is named:
      (1) Individual author(s): Surname first. Authors are preferably identified by initials of given names, but if the author uses only one given name it is spelled out: Butts, Charles. If necessary for unique identification, the first or both given names may be spelled out: Jones, John Josephus, III. In listing the last name, the author's own usage, if ascertainable, or the custom of his country should be followed. Otherwise, in general, if there is a prefix that is a definite article (La, Le, L') or a preposition and an article that form one word (Dall', Du, Della, Lo), the prefix is considered to be part of the surname. A prepositional prefix of a foreign name standing alone is not considered to be part of the surname. (See examples 10, 19, 32.) The prefix of an anglicized name is considered to be part of the

surname, but different families—or even different members of the same family—may have different preferences for spelling their names Du Pont, Du-Pont, Dupont; La Fayette, LaFayette, Lafayette; Vanderbilt, *but* Van Gessen, Van Valkenburg. Compound names are common in some countries; these names should ordinarily be cited under the first name of the compound. Diacritical marks, if applicable, follow the author's usage. (See examples 9, 19.)

(2) Corporate author (s) : See example 8.

b. If no author is named: Name of periodical in which published or name of publishing organization or sponsor (see example 24).

2. Year of publication. If year of publication is not shown but is known, it is given in brackets (see example 5). If the actual date of publication is known to be different from date shown in the imprint, both these dates should be given (see example 22).

3. Title of work cited, as taken from title page of book, heading of article, or face of map. If there is more than one edition of the work, the referenced edition must be indicated, otherwise the page reference in text may confuse the reader. If the typographical style of a title page omits needed punctuation, it should be supplied:

Philmont Country
The Rocks and Landscape of
A Famous New Mexico Ranch

in "References" would read: "Philmont Country [dash, comma, or semicolon] the rocks and landscape of a famous New Mexico ranch." If the reference is an abstract, the fact should be shown by inserting "[abs.]" just before the colon that follows the title (see example 15). If the reference consists of only part of a publication, care should be taken to make clear what is the part and what is the whole; "pt. 2 *of*," "v. 6 *of*," and "in" are helpful in making this distinction clear (see examples 3, 7, 14). A colon follows the title.

4. a. For books, the order after the colon is (1) place of publication, (2) publisher's name, and (3) pagination exclusive of preliminary matter paged in Roman numerals.

b. For series of publications or for articles in periodicals, give (1) name of periodical or series, (2) the place of publication and publisher's name if needed to identify the publication, (3) volume and number, as pertinent, in Arabic numerals, and (4) pagination.

c. For maps, the reader will probably be interested in the scale and in the number of sheets if more than one (see example

6). Mention of scale is particularly important if the map cited is a source for a compilation map at another scale.

d. Citation of the proceedings or other publications of congresses, conferences, and similar meetings should include (1) name of the congress or conference, (2) number of meeting, if any, (3) the city (or city and country) and year of the meeting, (4) title of the publication, and (5) collation (series, volume, part, pagination) if meaningful. If the organization held more than one meeting in a calendar year, the exact date of the meeting should be given. The information may be given in whatever order best approximates the order of the title page (or cover, if there is no title page) of the publication.

The parts of the author-year-title and of the place-publisher and publication-collation elements are usually separated by commas, but a semicolon or a period may be used if needed for clarity (see example 16).

In naming the corporate author or the publishing organization, the order is from the larger to the smaller unit:

U.S. Treasury Department Internal Revenue Service
Michigan Department of Conservation
U.S. Atomic Energy Commission Technical Information Service
U.S. Navy Bureau of Ships
American Institute of Architects and Engineers Joint Council Committee

The full corporate name is not needed in listing most commercial publishers. Thus, "Merriam" is sufficient to identify "G. & C. Merriam Co.," "Macmillan" is enough for "The Macmillan Company," and "John Wiley" for "John Wiley and Sons, Inc." If the publication or the publisher is likely to be difficult to identify, more detailed information may be needed.

The Government Printing Office is given as the publisher of reports issued by special or temporary Federal bodies but is ordinarily not listed in citations of reports issued by permanent Federal agencies.

The abbreviations "U.S." and "U.S.S.R." or "SSSR" are used, but names of other countries and of States, provinces, and cities should be spelled out. Other abbreviations in the reference list should be limited to those for collation terms (ser., v., sec., pt., no., p.) and for descriptive terms such as "edition," "abstract," and "supplement." The other reference information should be given in complete form.

In general, Arabic numerals are substituted for Roman numerals unless the Roman numerals appear in a title or in a cited page reference, as "Baker (1958, p. iii–xiv)."

Collation terms of foreign publications are given by their approximate English equivalents as far as possible.

	Volume	*Part*	*Number*	*Page*
Bohemian (Czech)	svazek, kniha	část	čislo	strana
Danish	bind, aargang	del	nummer, hefte	side
Dutch	boekdeel, jaargang	aflevering, deel	nummer	bladzijde, pagina
French	volume, tome, année	part, fascicule	numéro	page
German	Band, Jahrgang	Teil	Nummer, Heft	Seite
Greek	τόμος	μέρος	αριθμός	σελις
Hungarian	kötet	rész	szám	lap
Italian	volume, anno	parte	numero	pagina
Norwegian	bind	del	nummer, hefte	side
Polish	rok, ksiazka, tom	cześć	numer	stronca
Portuguese	volume, tomo, anno	parte	numero	pagina
Russian	том	часть	выпуск номер	страница
Spanish	volumen, tomo, año	parte	número	página
Swedish	volym, band	del	häfte, nummer, numro	sida, page
Turkish	cilt	cüz	sayi	sahife

Examples of cited references

The sequential numbers of the following examples are for reference in this book. Citations in Survey manuscript reports should not be numbered.

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Additional reading

The bibliographic style detailed in the preceding pages is the style of the Survey only. There are probably as many bibliographic styles as there are publishing organizations, and the Survey author pointing his report to a particular outside journal should familiarize himself with that journal's bibliographic style. Some basic principles of bibliography are given in the University of Chicago style manual (p. 371–388). The Library of Congress (LC) has published a guide to its bibliographical procedures and style which gives, by each element of the entry, the LC style for listing documents, serials, and books, pamphlets, and other monographic publications. The guide contains a selected list of references on bibliographic procedures and techniques (p. 113–115); it was published in 1954 and reprinted with a list of abbreviations in 1966.

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TABLES

A well-constructed table is a concise and effective means of presenting related data. Table construction is a minor but complex art; it has its basic laws, conventions, and obscure connotations as does any other art or science. For Survey tabular style the principal guide and source of detailed information is the GPO style manual (1973, p. 187–225); other sources are Jenkinson (1949) and University of Chicago (1969, p. 273–294). The tabular styles of these three guides differ a little from each other and from Survey tabular style, so the author might profitably seek editorial advice on drafts of tables before putting them into final manuscript form.

Samples of tables of more or less standard format for Survey papers are given at the end of this section and in the sections on water resources and on stratigraphy. Tables in some reports published during the period of conversion from English units of measure to the International System of Units will give measurements in both metric and English units.

In constructing tables of unique format, the author should be aware that the simpler the table's design, the more effective its communication. A very complex table can become almost a form of cryptogram. Readers are timid creatures, easily frightened into turning to the next page, and a Great Horned Table is enough to frighten the hardiest reader into turning to the next book. Several simple, easily understood tables may be preferable to one overly complex table.

Tables should, so far as possible, be constructed to fit narrow measure on the page. It is difficult for the eye to follow a parallel (double-page) table across the gutter even if the registry of the two pages is accurate, and it is irritating to the reader to have to turn the publication back and forth to read a wide-measure table. However, some long-used and useful Survey tables have parallel formats; still others have wide-measure formats.

A table should be introduced by a statement in the text, but this statement should not duplicate the table title. As a rule, a table should have a brief title that indicates the principal items of information included, but short tabulations that are introduced in the text with some such statement as "The following table shows * * *" may not need a title. Phrases such as "Table showing" and "Number of" are not needed in a table title.

Most tables are numbered for convenience of reference, although a table that can immediately follow its only reference need not be numbered. Tables are numbered in order of their physical placement in the report. If a long table or tables would break up the continuity of the text matter, the author may consider placing the table (s) at the end of the report, after the reference list and before the index.

The terminology and order of the table title should correspond to the terminology and order of items in the body of the table, and consistency of terminology should be maintained among tables, illustrations, and text. If the table title reads "Analysis of samples," the text references and the body of the table should not use "specimen," "fraction," or other term interchangeably when referring to what the title calls "samples."

Except for a specialized, seldom-used form of table consisting entirely of figures, the body of a table consists of a stub column or block and related data reading across from the stub. The stub should be arranged in some logical sequence: alphabetical, chronological, numerical, stratigraphic, east to west, north to south, smallest to greatest, downstream, upstream, or such, and the order should be stated if it is not readily apparent. If a lengthy table has become far advanced in preparation before the matter of logical order has had proper attention, a first column may be added as a patchwork remedy simply to give the stub item is a lengthy phrase. Reference to "item 26 of table 4" may bt useful in tables that are to have many text references, particularly if the stub item is a lnegthy phrase. Reference to "item 26 of table 4" may be preferable to repetition of "laccoliths related to East Mountain stock (table 4)."

Generally, the factor that governs the order of a table should be the stub column; for example, if table entries are in chronological sequence, the pertinent dates usually will be either the stub column or a column of the stub block. Again speaking generally, only one type of data should be entered in one column of a table, though a "Remarks" final column may be preferable to an excessive number of columns for miscellaneous bits of data.

Only in first or last column may space be left blank in the body of a table. If a test was made and the material or condition tested for was not found the proper entry is "0." If no test was made, if no data are available, if the column factor is not applicable to the stub item, leaders or an applicable symbol (n.d., n.a.) should be entered and the symbol should be explained in the headnote.

Except for tables that are forwarded as camera-ready copy, long tables consisting mainly of statistical matter may be submitted in handwritten form, provided always that they are clearly legible. Manuscript tables in engineer's lettering are fully acceptable.

Each manuscript table should be on a separate page or pages because it probably will be set in type by different workers from those setting

the text. A typed manuscript table should be double spaced and should have wide margins all around, to allow space for instructions to the printer.

Explanatory remarks pertaining to the title or to the whole table should be given in a bracketed headnote, written in telegraphic style, and centered just below the title. If the headnote is lengthy, as are those of some tables, it may not be bracketed. The footnote reference numbers of each succeeding table start with the numeral 1; they are indicated by superior figures ([1] [2] [3] . . .) and are written in numerical order from left to right across the page, beginning with the first line then going across each succeeding line. Leaders are used in the stub column and across the entire table, except that they are omitted from a last reading column or a first or last date column. Detailed instructions for the placement of footnotes, references, and leaders are given in the GPO style manual (1973, p. 202–203, 205). As an economy measure, downrules are not supplied unless specifically requested.

The following tables are examples or adaptations that have been published in Survey reports.

Sample tables

SAMPLE TABLE A.—*Mean bulk densities of rock specimens in the Haile-Brewer area*

Lithologic unit	Number of samples	Mean bulk density (g/cm^3)	Range of density
Intrusive rocks			
Granite	8	2.69	2.62–2.82
Do [1]	10	2.65	2.62–2.69
Do [2]	36	2.64	2.40–2.72
		[3] 2.65	
Gabbro	5	2.93	2.84–3.05
Do [2]	7	2.98	2.91–3.03
		[3] 2.96	
Diabase	55	2.97	2.79–3.08
Do [2]	13	2.91	2.86–2.98
		[3] 2.96	
Felsic hypabyssal rocks	12	2.58	2.38–2.69
Mafic hypabyssal rocks	4	2.92	2.92–3.07
Carolina slate belt rocks			
Sedimentary rocks	8	2.64	2.42–2.77
Do [2]	5	2.61	2.40–2.81
Mica gneiss [2]	3	2.73	2.67–2.80
Volcaniclastic rocks	8	2.59	2.38–2.74
Do [4]	13	2.79	2.63–2.99
		(2.84)	(2.70–3.05)
		[3] 2.69	

[1] Sloan (1908, p. 217–225).
[2] Waskom and Butler (1971, table 2, p. 2835).
[3] Weighted average mean.
[4] McCormick County, S.C., drill core samples as much as 300 feet below the collar elevation; figures in parentheses are powder-density values for the same samples and are not included in average.

SAMPLE TABLE B.—*Lead consumption in the United States, by products, in 1969*

[Data from U.S. Bureau of Mines Minerals Yearbook, 1971]

	Short tons
Metal products:	
Ammunition	79,233
Bearing metals	17,406
Brass and bronze	21,512
Cable covering	54,203
Casting metals	9,918
Caulking lead	44,857
Collapsible tubes	12,484
Foil	5,881
Pipes, traps, and bends	19,407
Sheet lead	25,818
Solder	72,626
Storage batteries:	
Battery grids and posts	280,386
Battery oxides	302,160
Terne metal	1,583
Type metal	25,660
Total	973,134
Pigments:	
White lead	6,617
Red lead and litharge	79,898
Pigment colors	14,670
Other	1,201
Total	102,386
Chemicals:	
Gasoline antiknock additive	271,128
Miscellaneous chemicals	602
Total	271,730
Miscellaneous uses:	
Annealing	4,252
Galvanizing	1,797
Lead plating	406
Weights and ballast	17,366
Total	23,821
Other, unclassified uses	18,287
Grand total [1]	1,389,358

[1] Includes lead that went directly from scrap to fabricated products.

SAMPLE TABLE C.—*Chemical analysis of*

[Results in milligrams per litre except as indicated. T, trace; Pres, present; <0.1, less than 0.1; as

Borehole: Serial numbers are assigned by the Kenya Water Department to all boreholes in Kenya. The prefix, C–, should be added to all serial numbers listed in this table.
Date of collection: Month, day, and year of collection of sample.
Depth: In metres below land surface.
Temperature: Temperature of water, in degrees Celsius.
Specific conductance: In micromhos at 25° C.

Borehole	Date of collection	Depth	Temperature	pH	Specific conductance	Dissolved solids	Silica (SiO_2)	Iron (Fe)	Manganese (Mn)	Calcium (Ca)	Magnesium (Mg)
Mandera District											
2570	9– 6–56	41.5	---	8.7	-----	3,280	13	0.20	---	184	4
2570	9–26–61	41.5	---	7.3	5,300	4,080	25	.10	---	186	---
2571	11–13–56	41.8	---	6.9	-----	2,730	24	.40	---	174	152
2616	12–28–56	91.5	---	--	-----	4,070	36	T	---	314	255
3297	6–24–64	45.7	---	7.3	7,500	4,870	25	0	---	189	188
3569	3– –69	84.5	---	7.7	4,500	2,810	90	>.1	---	170	145
3571	4– –69	125.0	---	7.9	5,100	2,990	10	>.1	---	213	209
3572	4– –69	125.0	---	7.7	4,900	2,830	30	>.1	---	98	164
3696	10–10–70	122.0	---	7.7	4,100	2,870	100	0	---	194	136
3850	8– 5–72	133.6	---	7.7	13,800	11,900	20	.20	---	628	475
3851	9–19–72	76.2	30.0	7.6	3,800	2,840	60	.20	---	192	122
3861	9–15–72	88.7	30.5	7.7	4,250	2,980	60	.30	---	211	144
3865	11–21–72	244.0	---	7.7	3,200	2,550	30	.10	0.10	120	64
Wajir District											
2643	2– 4–57	122.0	---	7.8	-----	15,100	9	0.70	---	495	501
3041	7– 1–60	175.4	---	8.1	-----	11,400	25	T	---	428	---
3110	2–14–61	140.3	---	7.1	1,150	730	45	<.1	---	70	47
3155	8–30–63	186.4	---	9.1	2,600	1,450	1	---	---	9	---
3218	3–13–63	143.9	---	7.5	1,100	765	35	0	---	27	---
3218	9– 7–71	143.9	36.2	7.9	1,080	720	50	.20	0	27	18
3306	8–12–64	119.0	---	7.5	2,400	1,480	10	0	---	82	58
3306	8–12–64	145.5	---	7.5	2,400	1,540	10	0	---	90	67
3306	9–18–64	263.0	---	7.9	-----	3,750	---	0	---	309	118
3527	12–18–68	32.0	---	7.3	-----	4,250	8	T	---	135	---
3541	5–22–72	45.7	29.5	8.3	1,360	720	60	0	---	36	38
3549	4–20–70	45.7	---	7.8	1,200	1,460	60	.40	---	29	93
3654	8–25–71	134.2	36.2	8.4	1,080	740	50	.40	---	25	39
3655	5–23–70	120.2	34.0	7.7	1,000	795	35	.40	0	31	17
3656	1–31–70	20.4	---	7.8	650	472	110	>.1	>.01	15	57
3657	1– 4–70	61.0	---	7.7	1,200	870	40	0	.01	61	42
3658	3–19–70	61.0	27.5	7.8	1,000	764	35	0	0	31	34
3685	8– 6–70	108.3	34.0	7.8	1,200	920	60	>.01	0	19	25
3686	8– 6–70	183.0	33.0	7.8	2,600	1,700	20	0	---	264	85
3687	8–26–70	121.7	36.7	8.0	700	420	25	.15	---	22	7
3715	2–20–71	136.9	---	7.7	700	480	40	.20	---	39	25
3726	7–11–72	140.0	---	9.0	2,050	1,290	5	.40	---	2	0
3727	5–26–71	144.3	---	7.7	750	545	20	.40	---	17	11
3769	8–25–71	132.1	---	7.5	4,500	2,750	30	0	---	12	31
3788	2– 9–72	119.5	37.6	8.3	710	460	40	.10	---	30	25
3792	3–19–72	112.8	---	7.7	1,220	740	50	0	---	40	43
3811	4– 1–72	128.7	---	7.5	15,500	11,000	15	.10	---	200	390
3820	5–28–72	128.7	37.5	7.4	820	535	30	0	---	30	14
3821	6– 6–72	147.9	---	7.3	1,550	830	35	0	---	105	51
3828	6–26–72	224.2	---	7.7	12,600	10,800	10	.20	---	560	324
3880	2–19–73	76.2	---	7.3	20,600	15,800	50	0	---	1,780	1,330
3881	3–17–73	94.8	---	7.5	4,400	2,960	60	---	---	260	300
3891	2–24–73	32.9	---	8.4	1,240	824	50	.10	.04	48	53
3893	5–10–73	205.1	---	8.2	2,550	1,500	30	.10	---	7	6
3899	5– 8–73	84.0	33.0	7.7	6,200	3,660	80	.30	.10	208	50
3914	5–23–73	149.3	---	6.9	5,500	3,190	10	.10	.30	110	10
3915	6–10–73	117.0	---	7.8	6,500	5,000	70	0	---	56	65
3917	6–22–73	205.3	---	7.8	9,500	8,800	20	0	0	285	410
3918	6–12–73	158.0	---	8.4	9,100	6,190	50	.5	.2	144	168
3931	8–21–73	152.0	---	7.3	4,200	2,650	20	.20	---	326	81
Garissa District											
2485	8– 6–55	128.4	---	8.1	-----	720	4	0.3	---	---	---
2685	6–18–57	93.9	---	7.1	-----	710	26	1.5	---	71	45
2686	6–18–57	109.2	---	8.1	-----	805	13	1.5	---	---	---
2687	7– 1–57	54.9	---	8.1	-----	22,100	10	.8	---	---	---
2718	8–24–57	78.1	---	7.5	-----	35,400	12	.7	---	315	437
2719	2–14–61	79.3	---	6.9	33,000	25,900	30	0	---	392	---
3033	7–26–60	134.2	---	7.9	-----	6,910	25	0	---	22	---
3038	7–26–60	101.5	---	7.3	-----	12,800	40	.2	---	126	---
3070	10–12–60	97.6	---	7.3	13,300	9,520	25	0	---	214	164
3085	12–12–60	128.1	---	7.5	1,550	1,040	25	.3	---	---	---
3120	3–13–61	70.4	---	7.1	1,430	1,200	35	0	---	157	62

waters from boreholes, northeastern Kenya

>0.1; more than 0.1 Analyses by Kenya Government Chemist's Department, Nairobi, except indicated]

Dissolved solids: Residue on evaporation at 180° C.
Aquifer: A, alluvial deposits of Quaternary age; P, semi-consolidated deposits (Merti Beds) of Pliocene age: M, consolidated sedimentary rocks of Mesozoic age; C, crystalline rocks of Precambrian age.
Remarks: S, analysis by British Petroleum-Shell Co., Ltd.

Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Sulfate (SO_4)	Chloride (Cl)	Nitrate (NO_3)	Nitrite (NO_2)	Fluoride (F)	Hardness as $CaCO_3$	Hardness noncarbonate	Aquifer	Remarks
Mandera District—Continued												
----	---	308	132	469	1,400	0	T	0.8	476	----	A	
----	---	---	---	646	1,770	0	0	----	1,100	----	A	
----	---	208	---	552	1,370	----	---	.7	1,060	----	A	
----	---	504	---	646	1,470	T	T	1.0	1,840	----	M	
1,180	30	---	---	816	2,050	0.3	0.01	.3	1,260	----	A	
475	19	258	0	323	1,060	222	.07	2.0	1,030	----	M	
470	40	238	0	533	1,630	.5	T	1.0	1,400	----	M	
590	56	380	0	440	1,080	100	.12	1.0	927	----	M	
560	20	329	0	347	1,190	71	.3	1.2	1,030	760	M	
2,160	143	234	0	4,200	4,140	20	.3	1.2	3,550	3,358	M	
490	24	351	0	192	1,030	155	.09	2.0	1,030	740	M	
535	26	342	0	347	1,160	177	.1	1.6	1,120	840	M	
508	13	342	0	960	220	6.2	T	1.1	566	286	M	
Wajir District—Continued												
----	---	200	---	1,415	8,170	T	T	1.2	3,300	----	P	
----	---	---	---	572	6,080	0.6	0.09	1.8	2,970	----	P	
----	---	---	---	42	148	42	2.0	2.5	350	35	P	
455	36	---	---	123	690	3.8	1.4	8.2	210	----	P	
220	---	---	---	56	88	.4	0	1.0	210	----	P	
240	16	---	---	55	67	0	.01	1.1	218	----	P	
333	45	---	---	85	644	27.5	2.3	1.1	445	----	P	
333	45	---	---	92	644	27.5	5.5	1.0	500	----	P	
860	44	---	---	73	2,010	38	.06	1.3	1,240	----	P	
----	---	128	---	76	2,170	----	---	.6	2,380	----	C	
158	11	356	29	40	174	62	.30	1.8	340	32	C	
109	3.5	674	0	56	248	10	<.03	4.7	456	0	C	
190	16	617	65	59	67	0	.03	1.2	224	0	P	
184	13	586	0	47	100	2.2	.03	2.3	148	0	P	
30	10	366	0	----	18	22	.3	----	276	0	A	
120	4	374	0	89	144	7.8	<.03	3.64	324	0	C	
100	4	340	0	88	120	3.3	<.03	1.62	296	0	C	
320	20	586	0	105	109	22	.03	1.6	152	0	P	
190	13	493	0	263	510	39	.3	1.7	1,010	608	M	
96	11	390	0	43	34	.6	0	.4	83	0	P	
102	11	440	0	24	64	1.0	.01	.7	204	0	P	
490	8	932	118	24	150	0	.03	4.2	6	0	P	
174	7	478	0	30	50	0	0	1.4	88	0	P	
880	17	644	0	192	816	0	.07	1.9	160	0	P	
100	15	344	29	21	40	.4	.01	.7	182	0	P	
176	21	512	48	55	140	4.4	0	.4	280	0	P	
2,740	34	220	0	467	5,200	199	.4	.7	2,124	1,940	C	
132	13	434	0	19	58	0	0	.7	170	0	P	
104	16	371	0	31	256	24	.04	.2	304	170	P	
1,544	42	268	0	2,567	3,900	0	.7	1.5	2,750	2,530	M	
1,440	65	106	0	600	7,500	443	.1	.9	10,000	9,890	C	
300	33	403	0	168	1,120	443	.02	1.1	1,900	1,570	C	
170	2	444	34	59	150	8.8	.03	1.3	340	0	C	
524	16	508	2.4	183	576	3.5	0	1.2	44	0	P	
386	47	417	0	109	1,480	354	.1	1.3	724	382	C	
755	15	93	0	24	1,920	.4	.1	1.0	314	238	M	
1,200	116	486	24	267	2,850	0	.01	.7	2,420	0	P	
1,690	143	347	4.8	700	4,600	133	.15	1.0	1,060	2,130	C	
1,300	82	547	34	563	2,800	61	.1	2.8	1,150	556	C	
350	35	229	0	493	980	354	.2	.5	188	966	C	
Garissa District—Continued												
----	---	470	---	25	94	T	T	0.7	60	8	P	
----	---	400	---	31	142	T	T	3.0	362	34	P	
----	---	660	---	25	65	0	T	1.8	40	----	P	
----	---	1,330	---	1,580	11,400	T	T	9.4	80	----	P	
----	---	610	---	2,450	11,900	0	T	15.2	2,580	2,080	P	
----	---	---	---	2,430	12,900	6.6	0	3.3	2,800	----	P	
----	---	---	---	671	3,180	16.0	1.2	2.3	390	----	P	
----	---	---	---	2,130	5,500	0	0	1.1	985	----	P	S
----	---	---	---	1,360	4,410	0	0	1.6	1,210	----	P	S
----	---	---	---	107	164	0	0	2.0	80	----	P	
----	---	---	---	499	122	0	0	2.5	650	----	P	S

SAMPLE TABLE D.—*Chemical analyses of water from typical middle-zone boreholes, Chad Basin, Nigeria*

[Results in parts per million except as indicated]

Constituents	Mbutta, Mafa District GSN 1648 [1]	Laraba, Gubio District GSN 1992 [1]	Garunda, Kanembu District GSN 2083 [1]	Nyau, Kanembu District GSN 2091 [1]	Sabsawa, Nganzei District GSN 1984 [1]	Shuari, Mafa District GSN 1643 [2]	Kauwa, Kanembu District GSN 3020 [2]	Ngala, Ngala District GSN 1996 [2]	Dalori, Konduga District GSN 2274 [2]
Silica (SiO_2)	48	67	69	63	52	109	65	66	66
Aluminum (Al)	Trace	Trace	Trace	Trace	.03	Trace	.1	.1	.1
Copper (Cu)	-----	------	------	----	-----	----	.02	0	.04
Iron (Fe)	.18	1.5	1.3	1.3	.6	.1	4.5	[3].25	[3]7.0
Manganese (Mn)	1.0	8.5	4.2	2.5	1.0	2.4	1.4	.55	1.2
Calcium (Ca)	19	64	51	45	7	25	50	8	14
Magnesium (Mg)	4.0	37	23	20	3.7	19	22	4.1	6.8
Sodium (Na)	85	192	180	188	70	141	243	176	76
Potassium (K)	16	23	18	19	13	18	18	9	14
Bicarbonate (HCO_3)	183	170	237	243	160	268	295	354	-------
Sulfate (SO_4)	61	449	320	319	43	180	368	83	29
Chloride (Cl)	32	112	88	88	23	41	71	34	10
Fluoride (F)	.3	.6	.6	.6	.10	.2	-------	-------	-------
Nitrate (NO_3)	.6	0	13.3	13.3	.4	6.6	0	.8	.1
Dissolved solids, residue on evaporation	536	1,065	890	885	288	678	955	543	[3]334
Hardness as $CaCO_3$	72	320	230	205	35	148	216	37	63
Free CO_2	-----	125	95	85	40	115	[3]95	[3]76	[3]95
Specific conductance, micromhos at 25°C	400	1,300	1,085	800	340	800	1,300	775	425
pH	6.6	6.2	6.4	6.4	6.4	6.3	[3]6.5	[3]6.7	[3]7.3
Sodium adsorption ratio (SAR)	4.7	4.7	5.3	5.9	5.3	5.2	[3]7.3	[3]12.8	[3]4.1
Oxidation-reduction potential (Eh)	-----	------	------	----	-----	----	[3]—79	[3]—39.5	[3]—163

[1] Analyzed by Geol. Survey of Nigeria Lab., Kaduna, Nigeria.
[2] Analyzed by U.S. Geol. Survey lab., Washington, D.C.
[3] Field determinations by Frank E. Clarke, U.S. Geol. Survey.

SAMPLE TABLE E.—*Principal sources and some potential sources of high-calcium limestone in the United States*

Geologic age	Stratigraphic unit	Principal areas of occurrence of high-calcium limestone
Eastern and Central United States		
Tertiary	Ocala Limestone	Northwestern peninsula, Florida.
Pennsylvanian	Vanport Limestone (also a member of the Alleghany Formation).	Western Pennsylvania, northern West Virginia, eastern Ohio.
Mississippian	Greenbrier Limestone	Northern West Virginia, southwestern Virginia.
	Bangor Limestone	Northern Alabama, northern Georgia.
	Maxville Limestone	Eastern Ohio.
	Ste. Genevieve Limestone	Eastern Tennessee, northern Alabama, Kentucky, Indiana.
	Girkin Formation (formerly Gasper Formation).	Western Kentucky, northern Alabama.
	St. Louis Limestone	Missouri, Illinois.
	Salem Limestone	Southern Indiana.
	Warsaw Limestone	Southern Indiana, Kentucky, northern Alabama.
	Boone Formation	Northern Arkansas.
Devonian	Helderberg Group	New York.
	Jeffersonville Limestone	Kentucky, southern Indiana.
	Traverse Formation, as used by Shaver and others (1970), or Group.	Michigan, Indiana.
	Cedar Valley Limestone as used by Thiel and Schwartz (1941).	Southeastern Minnesota.
	Rogers City Formation	Northeastern Michigan.
	Dundee Formation	Do.
	Columbus Limestone	North-central Ohio.
Ordovician	Holston Limestone	Eastern Tennessee, southwestern Virginia.
	New Market Limestone	Southwestern Virginia.
	Newala Limestone	Northern Alabama.
	Valentine Member of Curtin Limestone of Kay (1943).	Central Pennsylvania.
	Annville Limestone	Southeastern Pennsylvania.
	Trenton Limestone	New York.
	Galena Dolomite and Platteville Limestone.	Minnesota, Illinois, Wisconsin.
Cambrian	Tomstown Formation	Panhandle of West Virginia.
Western United States		
Quaternary	Shell beds	Southern California coast and Texas coast.
Tertiary	Sierra Blanca Limestone	Southwestern California.
	Vaqueros Formation	Do.
	Martinez Formation	Do.
Cretaceous	Mural Limestone	Southeastern Arizona.
	Edwards Limestone	Central and western Texas.
Tertiary to Jurassic	Franciscan Formation and metamorphic rocks of nearly equivalent age (limestone occurs as lenticular bodies).	Coastal Range and California and southwestern Oregon.
Jurassic(?)	Limestone of Kings River area.	Southern Alaska.
Triassic	Limestone of Snake River area.	Southwestern Idaho.
Triassic and Permian	Isolated limestone deposits.	Northeastern Oregon.
Permian	Ingleside Formation	North-central Colorado.
Permian to Mississippian	White Knob Limestone and Wells Formation.	Southeastern Idaho.
Carboniferous(?)	Oro Grande Formation	Central southern California.
Pennsylvanian or Mississippian.	Limestone lenses in metasediments.	Southwestern Oregon.
Mississippian	Madison Group	Western parts of Montana, Wyoming, and Colorado; southeastern Idaho, and northeastern Utah.

[Absence of cross rule at bottom indicates table is continued to next page. "Do." is capitalized in first and last columns if used in table, lowercased in any other column]

SAMPLE TABLE E.—*Principal sources and some potential sources of high-calcium limestone in the United States*—Continued

Geologic age	Stratigraphic unit	Principal areas of occurrence of high-calcium limestone
Western United States—Continued		
Mississippian—Continued		
	Escabrosa Limestone	Southeastern Arizona.
	Redwell Limestone	Northern Arizona.
Devonian	Crystal Pass Limestone Member of the Sultan Limestone.	Southern Nevada.
Silurian	St. Clair Limestone	Central and eastern Oklahoma.
	Heceta Limestone	Southeastern Alaska.
Ordovician	Fernvale Limestone	Central and eastern Oklahoma.
Cambrian	Meagher Limestone	Western Montana.
Paleozoic (undifferentiated).	Limestone of Pico Blanco	Southern coast of California.

References

Jenkinson, B. L., 1949, Bureau of the Census manual of tabular presentation: U.S. Bureau of the Census, 266 p.

"This manual is devoted largely to an outline of theory and practice in the presentation of statistical data in tables for publication, illustrated by specific examples throughout. The emphasis is placed upon principles, rather than rules * * *" (p. ix) in order to provide flexibility. The tabular style differs somewhat from GPO and Survey tabular styles, but the book contains much useful technical information and all needed definitions of tabular terms.

U.S. Government Printing Office, 1973, Style manual; Washington, 548 p.

University of Chicago Press, 1969, A manual of style (12th ed., revised): Chicago, 546 p.

NUMERALS

The recommendations listed below for use of numerals are either quoted from or based on the 1967 edition of the GPO style manual (p. 169–174), except as shown. Different editions of the manual have given somewhat different numeral-usage rules, but those of the 1967 edition generally seem to involve fewer problems in the way of exceptions to basic usages.

Most rules for the use of numerals are based on the general principle that the reader understands Arabic numerals more readily than Roman numerals or numerical word expressions, particularly in technical, scientific, or statistical matter. Some general rules follow.

1. Arabic numerals are preferable to Roman numerals.
2. Figures are used in text for both cardinal and ordinal numbers of "10" or more except for the first word of the sentence; most sentences can be so worded as not to begin with a number. Numbers under "10" are to be spelled out except for serial numbers and expressions of time, measurement, and money.

   Only four companies in the metals group appear on the list, though the 1970 census shows at least 4,400 establishments.

U.S. Geological Survey Bulletin 1 was published in 1883.
Petroleum came from 16 fields, eight of which were in two States.
Each of the five girls earned $2 an hour.
A team of four men ran the 1-mile relay in 3 minutes and 20 seconds.
Ten percent of the population owns 70 percent of the wealth.
First Congress; 82d Congress; 38th parallel; 141st meridian; first parallel

3. Fractions that are part of unit modifiers or that are joined to whole numbers are expressed in figures; fractions that stand alone are spelled out.

one-eighth, three-fourths
3½, 1¾ (*but* ½ to 1¾ pages)
½-inch pipe, ⅞-point rise, 0.9-inch spacing

4. Two sets of numbers should not be written in immediate succession. Instead of "The final survey makes the total distance of levels run in 1906 38,307 miles," write "The total distance of levels run in 1906 was 38,307 miles," or some other variation.

5. Indefinite expressions are spelled out. The words "nearly," "about," "around," "approximately" do not constitute indefinite expressions (GPO SM, 1973, p. 184).

a hundred wells; nearly 100 wells; 115 wells

6. In text, "million" and higher orders are spelled out as illustrated.

$12 million (*not* $12,000,000), *but* $12,649,042
$2.75 billion; $2,750 million; $2¾ billion
$500,000 to $1 million
4 million years, *but* 400,000 years

7. In Survey reports, dates are usually written as shown below.

March 3, 1879, is the official birthday of the U.S. Geological Survey. (Note comma after year.)
March 6 to April 15, 1975 (*not* March 6, 1975, to April 15, 1975); April 1975
For consecutive years, water years, fiscal years, and meteorological years, the contracted forms 1974–75, 1890–91, 1916–27, 1907–8 (*but* 1900–1901, 1895–1902) are used.

8. The following rules for use or omission of the comma in numbers are taken from the 1973 edition of the GPO style manual (p. 137):

a. The comma is used to separate thousands, millions, and higher numbers of four or more digits. Thus: 4,320; 50,491; 1,250,000.

b. The comma is omitted in built-up fractions, in decimals, and in serial numbers except patent numbers.

1/2500
1.0947
page 2632
1721–1727 St. Clair Avenue
Executive Order 11242
motor No. 189463
1450 kilocycles; 1100 meters (no comma unless more than four digits radio only)

Reference

U.S. Government Printing Office, 1967, Style manual, 512 p.; 1973, 548 p.: Washington.

QUOTATIONS

The author is obligated to quote only the exact words of the reference, not the typographical or compositional style (that is, the indentation, the larger or smaller type, the spacing), and there is no obligation to reproduce antiquated or incorrect spelling, capitalization, punctuation, and grammar except on the rare occasions when quaintness of form is to be preserved. Reproduction of incorrect spelling or grammar with the disclaiming "sic" is distracting to the reader and condescending to the original writer. It is no blot on the bright shield of scientific integrity to change a quoted inappropriate "is" to "are." If the author's conscience troubles him about such, he can write: "As Jones (1903, p. 462) stated, 'The limestone exposed on the hill and the bedrock in the area [are] * * *.'" It may be noted that present-day quotations from Chaucer, Shakespeare, and all the classicists of antiquity are much punctuated, much capitalized, and much re-spelled from their "original" versions.

"British English" and "American English" differ slightly in spelling, capitalization, and other features. A direct quotation from a foreign author should not be changed to conform to "American English," but with this exception most American journals and publishers, including the Survey, routinely change "British" to "American" usage. By the same token, an author who publishes in a journal outside the United States should expect to find his usage changed to conform to local customs.

Text changes in either direction may occasionally cause slight discrepancies between text and map explanations. Consistency between the two is highly desirable but, if expediency dictates that different usage be allowed to stand in the illustrations, most readers will be able to jump the hurdle from "colour" to "color" or from "dyke" to "dike."

Omissions in quoted matter are indicated by three asterisks (as preferred in GPO style manual), rather than by three periods as some editorial styles prefer. Quotations from foreign languages are usually translated into English; if presentation of the material in its original language is desirable, both the original and a translation should be given.

Italics

Use of italic type (indicated in manuscript by underscoring), should generally be reserved for:

1. Formal names of genera, species, and subspecies or varieties of plants and animals, as *Productus, Inoceramus fragilis, Ostrea congesta* Conrad, *Bulimina elongata subulata*. Names of families and higher groups are printed in Roman: Brachiopoda, Mollusca, Foraminifera.
2. Letter symbols in mathematical equations and most letter symbols used in physics. Chemical symbols, even in italic matter, are printed in Roman.
3. *See* and *See also* in indexes, glossaries, and like matter
4. Names of individual aircraft, spacecraft, and marine vessels:

   The Apollo 15 lunar module *Falcon* * * *; the command module *Endeavor* * * *.

   The successful completion of the mission of the B–29 Superfortress *Enola Gay* brought the Japanese representatives to the battleship *Missouri*.

   The *Eagle* has landed.

   The Skylab Earth Resources Experimental Package (EREP) high-density digital tapes * * *.

   ERTS (Landsat) multispectral images have a variety of geological applications.

   The U.S. Geological Survey research vessel *Don J. Miller* * * *.

In general, italics are not used for emphasis in Survey publications. Many devices other than italicization are available for indicating needed emphasis: boldface type for glossary items, run-in or vertical numbering for series items, indention or change of type size for quoted matter. Variation from usual punctuation or from usual word, phrase, or sentence order has infinite possibilities for attaining emphasis.

Abbreviations, Signs, and Symbols

Some abbreviations, signs, and symbols that are used in Survey reports under certain conditions are listed at the end of this section. The standard Survey format when using abbreviations is to enclose the spelled-out form in parentheses the first time the abbreviation is used in the text and in the abstract, as "* * * ANL (Argonne National Laboratory) * * *"; thereafter "ANL" only. In some papers, it may be more convenient or natural to give the spelled-out term first and the abbreviation in parentheses after the spelled-out term.

Many abbreviations are so widely known that they need not be defined. Among these are the abbreviations for common units of measure preceded by a numeral (such as "ft," "in.," "m"), common bibliographic terms ("fig (s).," "pl (s).," "no (s).," "p.," and others), com-

monly used abbreviations such as "a.m.," "p.m.," "Jr.," "Sr.," "A.D.," and "B.C.," and common arithmetic and chemical abbreviations. (Note: We are sometimes using "abbreviations" loosely to include "signs" and "symbols"; the distinctions in the three terms are somewhat hazy.)

Instead of defining the terms in text, an author may follow an alternative procedure of placing just after the table of contents a glossary with needed definitions. A third procedure is to include in the glossary only signs and symbols and to define the abbreviations in text. Any of these procedures is acceptable so long as consistency of format and usage is maintained and meanings are clear. Remember, though, that the abstract must be independently intelligible.

To abbreviate or not to abbreviate is to some extent a matter of choice and judgment; "when in doubt, spell it out" is a good maxim to follow. A word or phrase used only a few times in a paper probably would not be abbreviated, but the same word or phrase used frequently would be shortened. In general, the more technical the paper the more appropriate will be abbreviations. Abbreviations are used freely in tables, which have rigid space limitations; such abbreviations should be defined in a headnote if they have not been defined earlier in the report. Matter in parentheses or footnotes is usually shortened as much as possible in order to avoid interrupting the main thought; the author probably would write "On page 64, Smith (1972) says that * * *," *but* "Smith (1972, p. 64) says that * * *."

In addition to the approved terms listed, the author may occasionally find it desirable to set up and define arbitrary abbreviations for his particular paper. However, little space is saved by abbreviations, and abbreviations unique to a particular paper may be especially confusing to the reader.

Many compilations of abbreviations are available, though no two follow exactly the same style, and so may be more confusing than enlightening. The three publications listed below are only a few of such dictionaries in print.

1. A 36-page "Scientific and Technical Abbreviations," which includes symbols, was edited and published in 1970 by the John F. Holman Company, of Washington, D.C.
2. In the same year, Bowker of New York published the second edition of Paul Spillner's "World Guide to Abbreviations," a three-volume "list of more than 50,000 abbreviations with an internal bibliography of dictionaries of abbreviations." The three volumes contain a total of 1,295 pages.
3. The "New Fourth International Edition" of "Abbreviations Dictionary," by Ralph De Sola, was published in 1974 by American Elsevier Publishing Company of New York. It includes "abbreviations, acronyms, anonyms, contractions, initials and nicknames, short form and slang short cuts, signs and symbols." The dictionary has 428 pages.

In general, abbreviations for scientific terms and for terms of measurement are not followed by periods; a period is used with the abbreviation for "inch (es)" to avoid confusion with "in" used as a preposition or adverb.

Some preferred usages, mostly excerpted or reworded from the GPO style manual or from earlier editions of STA, follow.

Geographic terms

1. "United States" is abbreviated when it precedes "Government" or the name of a Government organization. Except for U.S.S.R. or SSSR, names of foreign countries are not abbreviated.

   British, French, and United States Governments
   U.S. Government
   U.S. Department of the Interior

2. The State names Alaska, Hawaii, Idaho, Iowa, Maine, Ohio, and Utah are not abbreviated except in postal addresses. The names of trust territories and insular possessions and localities, except as noted in "3" below are also not abbreviated.

   Catalina Island
   Island of Tutuila
   Johnston Atoll
   Long Island
   U.S. Trust Territory of the Pacific Islands

3. Names of States not listed in "2" above and of Canal Zone, Puerto Rico, and Virgin Islands are abbreviated immediately following any capitalized term. These names are spelled out after a lowercased word.

   Charlotte Amalie, V.I.
   Cleburne County, Ark.
   Ely Mining District, Nev.
   Friendship Airport, Md.
   Hima Quadrangle, Ky.
   Panhandle Gas Field, Tex.
   Richmond, Va.
   St. Lawrence County magnetite district, New York
   San Juan, P.R.
   San Juan Mountains, Colo.
   San Nicolas Island, Calif.
   Savannah River Basin, Ga.
   Tacoma area, Washington
   Taconic region, New York

4. The following abbreviations are preferred by GPO and by the Geological Survey. Note that some names are not abbreviated, except for two-letter Postal Service abbreviations that are normally used only with "ZIP code" mailing addresses.

Name	*Abbreviation*	*Postal Service*
Alabama	Ala.	AL
Alaska	Alaska	AK
Arizona	Ariz.	AZ
Arkansas	Ark.	AR
California	Calif.	CA
Colorado	Colo.	CO
Connecticut	Conn.	CT
Delaware	Del.	DE
Florida	Fla.	FL

Georgia	Ga.	GA
Hawaii	Hawaii	HI
Idaho	Idaho	ID
Illinois	Ill.	IL
Indiana	Ind.	IN
Iowa	Iowa	IA
Kansas	Kans.	KS
Kentucky	Ky.	KY
Louisiana	La.	LA
Maine	Maine	ME
Maryland	Md.	MD
Massachusetts	Mass.	MA
Michigan	Mich.	MI
Minnesota	Minn.	MN
Mississippi	Miss.	MS
Missouri	Mo.	MO
Montana	Mont.	MT
Nebraska	Nebr.	NE
Nevada	Nev.	NV
New Hampshire	N.H.	NH
New Jersey	N.J.	NJ
New Mexico	N. Mex.	NM
New York	N.Y.	NY
North Carolina	N.C.	NC
North Dakota	N. Dak.	ND
Ohio	Ohio	OH
Oklahoma	Okla.	OK
Oregon	Oreg.	OR
Pennsylvania	Pa.	PA
Rhode Island	R.I.	RI
South Carolina	S.C.	SC
South Dakota	S. Dak.	SD
Tennessee	Tenn.	TN
Texas	Tex.	TX
Utah	Utah	UT
Vermont	Vt.	VT
Virginia	Va.	VA
Washington	Wash.	WA
West Virginia	W. Va.	WV
Wisconsin	Wis.	WI
Wyoming	Wyo.	WY
Canal Zone	C.Z.	CZ
District of Columbia	D.C.	DC
Guam	Guam	GU
Puerto Rico	P.R.	PR
Virgin Islands	V.I.	VI

5. "Street" or "Avenue" as part of a name is not abbreviated.

14th Street Bridge Ninth Avenue Freeway

Descriptions of tracts of land

1. In the description of tracts of public land the following abbreviations are used (periods are omitted after abbreviated compass directions that immediately precede and close up on figures):

   SE¼NW¼ sec. 4, T. 12 S., R. 15 E., of the Boise Meridian
   lot 6, NE¼ sec. 4, T. 6 N., R. 1 W.
   N½ sec. 20, T. 7 N., R. 2 W., Sixth Principal Meridian
   Tps. 9, 10, 11., and 12 S., Rs. 12 and 13 W.
   T. 2 S., Rs. 8, 9, and 10 E., sec. 26
   T. 3 S., R. 1 E., sec. 34, W½E½, W½, and W½SE¼SE¼ sec. 32 (with or without a township number)

2. If fractions are spelled out in land descriptions, "half" and "quarter" are used (not "one-half" nor "one-quarter").

   south half of T. 47 N., R. 64 E.

Names and titles

1. "Railroad" and "Railway" are abbreviated in tables and in parentheses (as "Santa Fe Ry.," "Union Pacific RR."); preference between the two words follows the usage of the individual company.
2. A military title is usually abbreviated if followed by a given name or initial: "Col. H. M. Smith furnished data on the wells," but "Colonel Smith furnished * * *." The titles "Senator," "Congressman," and "Representative" are not abbreviated.

Dates

1. Names of months followed by the day, or day and year, are usually abbreviated in tables and in parentheses. In narrow columns of tables, the names of months may be abbreviated even if standing alone. Otherwise the form used in Survey reports is "January 1, 1976."
2. The two epochs of the Gregorian calendar are indicated by "A.D.," meaning "anno Domini" (in the year of our Lord), and "B.C.," (before Christ).

   A.D. 937 254 B.C.

3. Glacial and other geologic events may be expressed as an approximate number of years "B.P." (before present).

   10,000 B.P.

Time

1. Use "a.m. ('ante meridiem')," "p.m. ('post meridiem')," and "m. ('meridiem,' meaning 'noon')" with figures denoting clock time.

   3:30 p.m. 1 a.m.
   12 m. 12 p.m. (meaning "midnight")

2. If it is necessary to specify the time zone, the four conterminous U.S. zones are well enough known to Survey readers to be abbreviated as "e.s.t.," "c.s.t.," "m.s.t.," and "P.s.t." (or "e.d.t.," "c.d.t.," "m.d.t.," and "P.d.t."). Other zones should be spelled out, at least the first time used.

10 p.m. P.d.t.
1400 c.s.t. (for 24-hour time)
2:16 a.m. Bering standard time

Miscellaneous

1. The words "latitude" and "longitude" followed by figures are abbreviated, and the figures are closed up.

lat 52°33′05″ N., long 13°21′10″ E.

2. In citations of publications, "number" is abbreviated and lowercased. Elsewhere the abbreviation is capitalized.

Chemical Notes, v. 10, no. 41
Of all the specimens examined, No. 4297 most clearly illustrated the * * *

3. The degree mark should be used with figures in statements of dips and strikes, and the term of direction should be abbreviated.

dip of 10° SE., or 10° S. 35° E.
strike of N. 55° E., or N. 45°–70° E.
N. 55°30′25″ E.

But terms of direction should be spelled out unless figures are given: "The dip is southeast."

4. In tables, use "Do." (capitalized) in first and last columns for "ditto," "do." in other columns.

5. Over a stratigraphic figure column use "Meters," "M," "(m)," "Feet," "Ft In," "(feet)," or "(ft in)," according to the content of the column, to whether the term stands by itself or follows another term such as "Thickness," and to the amount of space available.

6. The English units of measure in unit modifiers are generally not abbreviated.

½-inch pipe
10-pound weight
30-foot well
0.9-inch bed

But as the metric units come into general use, economy of space may dictate abbreviation of the longer words.

10-km contour
5-ml solution
20-cm³ volume

Some abbreviations, signs, and symbols used in Survey reports

Compiled by ANNA MAY ORELLANA

[For abbreviations for stratigraphic terms, see sections on "Illustrations" (p. 54) and "Stratigraphic Nomenclature and Description" (p. 148); for normative minerals and groups, see section on "Petrologic Terminology" (p. 168); for chemical elements, see section on "Chemical Terminology" (p. 171)]

absolute____abs
absolute value of____| |
absorbance____A
absorptivity____a
absorptivity, molar____ϵ
abstract(s) ____abs.
academy____acad.
acceleration, angular____α
acceleration, linear____a
account____acct.
acre-foot____acre-ft
activity, chemical (absolute) ____λ
activity, chemical (relative) ____a
activity coefficient____γ
acute accent____$'$
administration, administrative__adm.
affinis____aff.
agricultural____agr.
alkylbenzenesulfonate____ABS
alternating current____ac
alternating-current (unit modifier) ____a-c
altitude____alt, h
American____Am.
American Chemical Society____ACS
American Geological Institute____AGI
American Geophysical Union____AGU
American National Standards Institute____ANSI
American Petroleum Institute____API
American Society for Testing and Materials____ASTM
ammonium dihydrogen phosphate____ADP
ampere____A
analytic (al) ____anal.
analytical variability____ξ_a
angle____$\angle$
angle between____$\wedge$
angle between a_0 and b_0 in the unit cell____γ
angle between a_0 and c_0 in the unit cell____β
angle between b_0 and c_0 in the unit cell____α
angle between the two optic axes of a biaxial mineral____$2V$
angstrom____A
angular frequency____ω
angular velocity____ω
anhydrous____anhyd
anno Domini (in the year of our Lord) ____A.D.
annual____ann.
ante meridiem (before noon) ____a.m.
anthropological____anthropol.
antilogarithm____antilog
appendix____app.
applied____appl.
approaches____$\rightarrow$
approximate (ly) ____approx
approximately identical with____$\approx$
approximately (nearly) equal to____$\approx$
April____Apr.
aqueous____aq
archeological____archeol.
area____A or S
article (s) ____art.
association____assoc.
asterisk____*
astronomic(al) ____astron.
astronomical unit (in English) ____AU
asymptotically equal to____$\simeq$
Atlantic standard time____A.s.t.
Atlantic time____A.t.
atmosphere____atm
atomic mass____m_a or m
atomic mass of species X____m (X) or m_X
atomic number____at. no., Z
atomic number of species X____Z (X) or Z_X
atomic weight____at. wt., M
atomic weight of species X____M (X) or M_X
atto (prefix) ____a
August____Aug.
automatic data processing____ADP
auxiliary____aux.
Avenue (in addresses only) ____Ave.
average____avg
average (indicated by bar or vinculum over symbol or by angular parentheses) ____—, $\langle\ \rangle$
Avogadro's number____N or N_A
avoirdupois__avdp

azimuth____az or α
bachelor of arts____B.A. or A.B.
bachelor of science____B.S. or S.B.
barn (area) ____b
barometer____bar.
barrel____bbl
base of natural logarithms____e
Baumé (used with degree) ____Bé
because____∵
becquerel____Bq
before Christ____B.C.
before present____B.P.
bench mark (in illustrations) ____BM
bench mark (in text) ____B.M.
benzene ring____ 
Bernoulli number____B
Bessel function (first kind, zero order) ____$J_0(x)$
Bessel function, hyperbolic (first kind, zero order) ____$I_0(x)$
bias____δ
bibliographic (al) __bibliog.
biennial____bienn.
billion years____b.y.
binary coded decimal____BCD
biochemical oxygen demand____BOD
biographic (al) ____biog.
biologic (al) ____biol.
Bohr magneton____μB
boiling point____bp
boldface____bf.
bolle (for example, Å in Swedish alphabet) ____°
Boltzmann constant____k
Boltzmann function____H
botanic (al) ____bot.
bottom withdrawal tube____BW-tube
Boulevard (in addresses only) ____Blvd.
braces____{ }
brackets____[ ]
Bragg angle, glancing angle (2θ is twice the glancing angle in X-ray diffraction) ____θ
breadth (width) ____b or B
breve____˘
Brinell hardness number____Bhn
British thermal unit____Btu
Brother (s) (commercial) ____Bro (s) .
building (s) ____bldg (s) .
bushel____bu
calculated____calc
calorie____cal
candela____cd
capacitance____C
carat____kt
caret____∧
caron____∨
Cartesian coordinates____x, y, z
catalog____cat.
cathode ray____CR
cathode ray tube____CRT
cedilla____¸
Celsius____C
centi (prefix) ____c
centimeter____cm
centimeter-gram-second (system) ____CGS
centimeter-gram-second (unit) ____cgs
central daylight time____c.d.t.
central standard time____c.s.t.
central time____c.t.
chapter____chap.
chemical____chem.
chemical oxygen demand____COD
chemical potential____μ
chi-square statistic____χ^2
circa (about) ____ca.
circle____○
circular (shape) ____cir
circumflex____∧
citrate-extractable heavy metal____cxHM
class____cl.
classification____classn.
coefficient____coef
cold-extractable copper____cxCu
collection (s) (used only with numbers) ____colln (s) .
college____coll.
cologarithm____colog
column____col.
commission, committee____comm.
common business oriented language____Cobol
communication (s) ____commun.
Company (commercial) ____Co.
comparative____comp.
compound____compd.
compressibility____κ
concentrate____conc
concentrated____concd
concentration____concn or c
conductance____G
conductivity____cond or γ
confer (to be compared to) ____cf.
conference____conf.
confidence limit, lower, for the population mean____μ_L
confidence limit, upper, for the population mean____μ_U
Congress, Congressional____Cong.
conservation____conserv.
consolidated____consol.
constant____const
constant as defined in text____K
continued____con.
contribution (s) ____contr.

control of electromagnetic radiation (civil defense) ____conelrad
cooperation, cooperative____coop.
Coordinated Universal Time____UTC
corner____cor.
Corporation (commercial) ____Corp.
corrected____cor
correlation coefficient____r
cosecant____csc
cosecant, hyperbolic____csch
cosine____cos
cosine, hyperbolic____cosh
cotangent____cot
cotangent, hyperbolic____coth
coulomb____C
counts per minute____c/min
Court (in addresses only) ____Ct.
critical____crit
Cross, Iddings, Pirsson, and Washington____CIPW
cross section of atoms and nuclei____σ
crystalline, crystallographic____cryst
crystallographic axes____a, b, c
cumulative frequency____c.f.
curie____Ci
cutting point in a hypothesis test____Ω
cycles per minute____c/min
cycles per second____c/s
cylinder____cyl
dagger____†
darcy, darcies____D
day____d
debye unit____D
decay constant____λ
decay constant based on alpha emission____λ_α
decay constant based on negative beta emission____λ_{β^-}
decay constant based on orbital electron capture____λ_ϵ or λ_{EC}
decay constant based on positron emission____λ_{β^+}
decay constant based on spontaneous fission____λ_{SF}
December____Dec.
deci (prefix) ____d
decibel____dB
decibel unit____dBu
Deep Sea Drilling Project____DSDP
degree____°
degree Celsius____°C
degree Fahrenheit____°F
degree rankine____°R
degree réaumur____°R
degrees of freedom____d.f.
deka (prefix) ____da
delta (finite change, increment, variation, difference) ____Δ or δ
density (mass) ____ρ
density (relative) ____d
department____dept.
depth____h
deuterium____D or ^{2}H
deuteron____d
development____devel.
diameter____diam, D or d
dichloro-diphenyl-dichloro-ethane (or delete hyphens and close up spaces) ____DDD
dichloro-diphenyl-dichloro-ethylene (or delete hyphens and close up spaces) ____DDE
dichloro-diphenyl-trichloro-ethane (or delete hyphens and close up spaces) ____DDT
dichlorophenoxyacetic acid____2,4-D
dielectric constant (permittivity) ____ϵ
dieresis; umlaut____¨
differential, partial____∂
differential, total____d or d
differential thermoanalysis____dta
dilute____dil
direct current____dc
direct-current (unit modifier) ____d-c
direction of extraordinary ray____E
direction of flow____→
direction of ordinary ray____O
discharge; total water discharge; rate of discharge; recharge____Q
disintegrations per minute____d/min
disintegrations per second____d/s
dissertation____dissert.
dissociation constant____K
dissociation constant, negative logarithm of; $-\log K$____pK
dissolved oxygen____DO
dissolved solids____DS
distilled____dist
distribution____distrib.
district____dist.
ditto (the same) ____do.
divided by____÷
doctor of philosophy____Ph. D.
document____doc.
dozen____doz
Drive (in addresses only) ____Dr.
dropping mercury electrode____dme
dry basis____DB
dyne____dyn
east____E.
eastern daylight time____e.d.t.
eastern standard time____e.s.t.
eastern time____e.t.

ecologic (al) ____ecol.
economic (al) ____econ.
edition (s) ____ed (s).
editor(s) ____ed (s).
educational____educ.
efficiency____eff
electric (al) ____elec
electric current____I
electric current density____J, j
electric field strength____E
electric flux____Ψ
electric potential____V
electromagnetic cgs unit____emu
electromotive force____emf, E
electron____e or e
electron mass____m_e
electron spin resonance____esr
electronvolt____eV
electrostatic cgs unit____esu
elementary charge____e
elevation____elev
emendatio (emended) ____emend.
end point____EP
energy____E
energy (kinetic) ____E_k
energy (potential) ____E_p
engineering____eng.
enthalpy____H
entomologic(al) ____entomol.
entropy____S
entropy (standard state of) ____$S°$
ephemeris time____ET
equal to____$=$
not equal to____$\neq$
equation (s) ____eq (s)
equilibrium constant____K
equivalent____equiv.
equivalent uranium____eU
equivalent weight____equiv wt
error function____erf
error function (complement to) ____erfc
(ethylenedinitrilo) tetraacetic acid disodium salt____sodium salt of EDTA
Euler number____E
ex grupo____ex gr.
exa (prefix) ____E
examination____exam.
exchangeable-potassium-percentage__EPP
exchangeable-sodium-percentage____ESP
excited hydrogen atom____H^*
Executive Document____Ex. Doc.
experiment____expt
experimental____exptl
explanation, explanatory____expl.
exponential of____exp, e
extension____ext.
extract, extracted____extr.
factorial product____!
faculty____fac.
Fahrenheit____F
farad____F
Faraday's constant (the faraday) ____F
February____Feb.
femto (prefix) ____f
figure (s) ____fig (s).
foot, feet____ft
foot-candle____ft-c
foot-lambert____ft-L
foot-pound-second (system) ____FPS
foraminiferal____foram.
force____F
force (moment of) ____M
formality____f
formula translator____Fortran
franc (money) ____F
freezing point____fp
frequency____f or ν
frequency (spectroscopy) ____ν
friction, coefficient of____μ or f
frontispiece____front.
Froude number____F
F-statistic for equality of variances____F
fugacity____f
function of x____$f(x)$
fusion point____fnp
gal____Gal
gallon____gal
gamma function____Γ
gas, as in H_2O (g) ____ (g)
gas constant____R
gas liquid partition chromatography____glpc
gauss____Gs or G
Geiger-Müller (unit modifier) ____G-M
geochemical____geochem.
geodetic____geod.
geographic (al) ____geog.
geologic (al) ____geol.
Geologic Names Committee of the U.S. Geological Survey____GNC
Geological Society of America____GSA
geophysical____geophys.
Gibbs free energy, Gibbs function____G
Gibbs free energy (standard state) ____$G°$
giga (prefix) ____G
government____govt.
gradient____∇
grain____gr
gram____g
grave accent____`
gravitational acceleration, acceleration of free fall, local acceleration due to gravity____g
gravitational constant____G

gray (unit of measure for absorbed dose) ____Gy
greater than____>
not greater than____$\not>$
much greater than____>>
greater than approximately equal to____$\gtrsim$
greater than or equal to____$\geqq$ or $\geqslant$
Greenwich civil time____G.c.t.
Greenwich mean astronomical time____G.m.a.t.
Greenwich mean time____G.m.t.
gross____gr
gross weight____gr wt
half-life____$T_{1/2}$
half-life, reduced____$fT_{1/2}$
handbook____handb.
haversine____hav
head, total____H
heat capacity____C
heat capacity at constant pressure____C_P
heat capacity at constant volume____C_V
hectare____ha
hecto (prefix) ____h
height____h
Helmholtz free energy____A
henry, henries____H
hertz____Hz
high-pressure (unit modifier) ____h-p
high-pressure metal vapor____HPMV
historic (al) ____hist.
horsepower____hp
hour____h
House bill (with number) ____H.R.
House Concurrent Resolution (with number) ____H. Con. Res.
House Document (with number) ____H. Doc.
House Joint Resolution (with number) ____H.J. Res.
House Report (with number) ____H. Rept.
House Resolution (with number) ____H. Res.
hydrogen ion activity, measure of____pH
hydrographic____hydrog.
hydrologic (al) ____hydrol.
hyperbolic functions, inverse, prefix to be added to abbreviation (for example, arcosh) ____ar
hypothesis (alternative) ____H_1
hypothesis (null) ____H_0
identical with____$\equiv$
not identical with____$\not\equiv$
imaginary square root of -1____i or j
inch (when used with ft, lb, exponents, omit period) ____in.
Incorporated (commercial) ____Inc.
indeterminate____indet.
index of refraction____n
indices of refraction for biaxial crystals____n_x, n_y, and n_z or α, β, and γ
indices of refraction for uniaxial crystals____n_O and n_E or ω and ϵ
inductance (mutual) ____M
inductance (self) ____L
infinity____∞
infrared____ir
inside diameter____ID
insoluble____insol.
institute, institution____inst.
integral____$\int$
integral, closed (circuital or contour) ____$\oint$
intensity of X-rays reflected from crystallographic planes____I
intermediate-pressure (unit modifier) ____i-p
internal____int
international____internat.
International Atomic Time____TAI
International Decade of Ocean Exploration____IDOE
International Geophysical Year____IGY
International Hydrological Decade____IHD
intersection or logical product____$\cap$
investigation (s) ____inv.
ionization constant____K or K_i
irrigation water classification: C denotes conductivity (electrical); S denotes sodium (SAR); numbers denote respective numerical quality classes____$C2$–$S3$
Jackson turbidity unit____Jtu
January____Jan.
Joint Oceanographic Institutions' Deep-Earth Sampling____JOIDES
joule____J
Joule-Thomson coefficient____μ
Junior____Jr.
kelvin____K
kilo (prefix) ____k
kilohm____kΩ
kilowatthour____kWh
K-meson____K
knot____kn
laboratory____lab.
lambert____L
langley____ly
Laplacian operator____∇^2
latitude (abbreviated only when used with figures) ____lat

length____l
less than____$<$
much less than____$<<$
not less than____$\not<$
less than approximately equal to____$\lesssim$
less than or equal to____$\leqq$ or $\leq$
library____libr.
limit____lim
limit of $f(x)$ ____lim $f(x)$
linear alkylsulfonate____LAS
linear combination____q
liquid____liq
liter____L
local standard time____l.s.t.
local time____l.t.
locality, localities (used only with numbers) ____loc (s).
logarithm (common) ____log
logarithm (natural) ____$\log_e$ or ln
logarithm of an observation____u
logical product or intersection____$\cap$
logical sum or union____U
longitude (when used with lat, omit period; abbreviated only when used with figures; use "long." if may be confused with adjective) ____long
longitudinal velocity; *P*-wave velocity ____v_P
low-pressure (unit modifier) ____l-p
lumen____lm
luminous flux____Φ
lux____lx
macron____$\bar{}$
magnetic field strength or intensity____$\boldsymbol{H}$
magnetic flux____Φ
magnetic induction____$\boldsymbol{B}$
Manning's roughness (resistance) coefficient____n
March____Mar.
mass____m
mass number____A
mass number of species X____A (X) or A_X
master of arts____M.A. or A.M.
master of science____M.S. or S.M.
mathematics (or mathematical) ____math.
matrix; for example $||\ a_{ij}\ ||$ or (a_{ij}) or $\boldsymbol{A}$____ $||\ \ ||$ or ( ) or $\boldsymbol{A}$
matrix, cofactor of element a_{ij}____$\boldsymbol{A}_{ij}$
matrix, conjugate____$\boldsymbol{A}^*$
matrix, determinant of; for example $|a_{ij}|$____$|\ \ |$
matrix, identity____$\boldsymbol{I}$
matrix, inverse____$\boldsymbol{A}^{-1}$
matrix, transpose____$\boldsymbol{A}^T$
maximum____max
maxwell____Mx
mean, a statistic to estimate the mean of lognormally distributed observations____m
mean life____τ
mean of a linear combination q____μ_q
mean of the lognormal distribution____α
mean of the negative binomial distribution____θ
mean of sample means____$\mu_{\bar{w}}$
mean of the variance of sample means____$\mu s^2_{\bar{w}}$
mean sea level____m.s.l.
mean square error____M.S.E.
mechanic (al) ____mech.
medical____med.
meeting (s) ____mtg.
mega (prefix) ____M
megohm____MΩ
melting point____mp
member of (used with a set and its elements) ____ϵ
memoir____mem.
memorandum____memo.
meta (in organic compounds) ____m
metallurgic (al) ____metall.
meteoritical____meteorit.
meteorologic (al) ____meteorol.
methylene-blue active substance____MBAS
meter____m
metric ton____t
micro (prefix) ____μ
micron____μ
microscopic (al) ____micros.
midnight____12 p.m.
mile____mi
military____mil.
Miller indices____hkl
milli (prefix) ____m
millimeter of mercury____mmHg
million gallons per day____Mgal/d
million years____m.y.
mineralogical____mineralog.
minimum____min
minus____$-$
minus or plus____$\mp$
minute____min
minute; prime; foot____$'$
miscellaneous____misc.
Miscellaneous Document (with number) ____Misc. Doc.
mixture melting point____mmp
Modified Mercalli____MM
molality, molal (concentration) ____m
molar concentration of substance B____c_B

molar mass of substance B____M_B
molarity, molar (concentration) ____M
mole____mol
molecular concentration____C
molecular weight____mol. wt
mountain, mountains____mtn., mts.
month____mo
motorship____MS
mountain daylight time__m.d.t.
mountain standard time____m.s.t.
mountain time____m.t.
multiplied by____$\times$
multiplying factor for the geometric mean of lognormally distributed observations____ψ_n
multiplying factor for the variance of lognormally distributed observations____ϕ_n
multispectral scanner____MSS
muon____μ
museum____mus.
myria (prefix) ____my
nabla; del; differential vector operator____∇
nano (prefix) ____n
national____natl.
natural____nat.
natural variability____ξ_n
nautical mile____nmi
neutrino____ν
neutron____n
new genus____n. gen.
new series____new ser.
new species____n. sp.
new variety____n. var.
newton____N
newton meter____N·m
Newtonian gravitational constant____G
no data____n.d.
no record, not reported____n.r.
nomen nudum____nom. nud.
noon____12 m.
normality, normal (concentration) ____N
north____N.
northeast____NE.
northwest____NW.
not available; not applicable____n.a.
not determined____n.d.
November____Nov.
nucleon number____A
number (s) ____no (s) .
number of observations in a population____N
number of observations (sample size) ____n
number of samples____k
observation____w
observed____obs
observed frequency of observations____O
oceanographic (al) ____oceanog.
October____Oct.
oersted____Oe
ohm____Ω
ohm centimeter____Ω·cm
ohm meter____Ω·m
optical directions in a crystal; also rays of light in these directions and pleochroic colors in these directions____X, Y, Z
ornithological____ornithol.
ortho (in organic compounds) ____o
ounce____oz
outside diameter____OD
oven dry basis____ODB
oxidation-reduction potential____Eh
Pacific daylight time____P.d.t.
Pacific standard time____P.s.t.
Pacific time____P.t.
page (s) ____p.
paleoecologic (al) ____paleoecol.
paleogeographic(al) ____paleogeog.
paleontologic (al) ____paleont.
Pan American____Pan Am.
para (in organic compounds) ____p
paragraph____par.
parsec____pc
part (s) ____pt (s) .
part (s) per billion____ppb
part (s) per million____ppm
partial pressure of oxygen or carbon dioxide____P_{O_2}, P_{CO_2}, or $P(O_2)$, $P(CO_2)$
particle-size diameter__ϕ
partition function____Z
pascal____Pa
pascal second____Pa·s
peck____pk
Peedee belemnite____PDB
pentaerythritol____PET
percentage risk of type I error____α
percentage risk of type II error____β
period____T
peta (prefix) ____P
petrographic (al) ____petrog.
petrologic(al) ____petrol.
phase____ph.
phenyl____Ph
philosophical____philos.
phot____ph
photogrammetric (al) ____photogramm.
photon____γ
physical____phys.
physiographic (al) ____physiog.
pico (prefix) ____p
pint____pt
pi (mathematical constant) ____π

pion____π
Place (in addresses only) ____Pl.
Planck constant____h
plate (s) ____pl (s).
plus____+
plus or minus____$\pm$
poise____P
Poisson ratio____ν or μ
polychlorinated biphenyls____PCB
polytechnic____polytech.
pooled sample variance____s_p^2
population coefficient of variation____γ
population mean____μ
population standard deviation____σ
population variance____σ^2
post meridiem (afternoon) ____p.m.
posterior distribution of a parameter θ____$D_1(\theta)$
potassium-adsorption-ratio____PAR
potential difference____V or U
pound (mass) ____lb
pound apothecary____lb ap
pound avoirdupois____lb avdp
pound-force____lbf
pound-force per square inch____lbf/in^2
power____P
precipitate____ppt, $\downarrow$
preliminary____prelim.
preparation variability____ξ_p
pressure____P or p
primary wave ____P-wave
prior distribution of a parameter θ____$D_0(\theta)$
probability of the event A____$P(A)$
proceedings____proc.
product of a series____Π
Programing Language/1____PL/1
project____proj.
proportion____: :
proportion of successes in a binomial population____θ
protium____^1H
proton____p
publication (s) ____pub (s).
pulsatance____ω
quadrangle____quad.
quantity of electric charge or electricity; quantity of heat; quantity of light____Q
quart____qt
quarterly____quart.
rad____rd
radar beacon____racon
radian____rad
radiance____B
radiant emissivity____J
radiant exposure____H
radiant energy____Q
radiant energy density____u
radiant flux____Φ
radiant intensity____I
radical; root; square root____$\sqrt{}$
radio detection and ranging____radar
radius____r or R
Railroad____RR.
Railway____Ry.
random fluctuation of "experimental error"____e
Range (s) (legal land term) ____R (s).
rankine (used with degree) ____R
ratio; is to____:
reactance____X
réaumur (used with degree) ____R
reconnaissance____reconn.
record(s) ____rec (s).
recrystallized____recryst
refractive index at 20°C, sodium (D) line____n_D^{20}
relative cumulative frequency____r. c. f.
repeating decimal; bar covers part that is to be repeated____ $1.\overline{14}$
report (s) ____rept (s).
resistance____R
resistivity____ρ
return beam vidicon____RBV
reversible reaction____$\leftrightarrows$
review (s) ____rev.
revolutions per minute____r/min
revolutions per second____r/s
Reynolds number____$\mathbf{R}$
Road (in addresses only) ____Rd.
roentgen____R
roentgen equivalent, man or mammal____Rem
roentgen equivalent, physical____Rep
root mean square____rms
rubidium acid phthalate____RAP
Rydberg constant____R or Ry
Rydberg constant for infinite mass____R_∞
Saint, Sainte, Saints____St., Ste., SS.
sample coefficient of variation____C
sample mean____$\bar{w}$
sample mean of logarithms____$\bar{u}$
sample standard deviation____s
sample variance____s^2
sample variance of logarithms____s_u^2
sampling variability____ξ_s
saturated calomel electrode____sce
science (s), scientific____sci.
secant____sec
secant, hyperbolic____sech
second____2d
second (time) ____s
second; double prime; inch____$''$

secondary wave____*S*-wave
section (s) (subdivision of township) ____sec(s).
sedimentary____sed.
seismographic____seismog.
seismologic (al) ____seismol.
Senate bill (with number) ____S.
Senate Concurrent Resolution (with number) ____S. Con. Res.
Senate Document (with number) ____S. Doc.
Senate Joint Resolution (with number) ____S.J. Res.
Senate Report (with number) ____S. Rept.
Senate Resolution (with number) ____S. Res.
Senior____Sr.
sensu lato____s.l.
sensu stricto____s.s.
September____Sept.
series____ser.
session____sess.
shear velocity; *S*-wave velocity____v_s
siemens____S
sine____sin
sine, hyperbolic____sinh
sine of the amplitude (an elliptic function) ____sn
single-degree-of-freedom statistic____Q^2
skewness of frequency distribution____sk
society, societies____soc., socs.
sodium, line in spectrum of____*D*
sodium-adsorption-ratio____SAR
solid, as in AgCl (s) ____(s)
solid angle____ω
solidus____/
soluble____sol
solution____soln
sound fixing and ranging____sofar
sound navigation and ranging____sonar
south____S.
southeast____SE.
southwest____SW.
Soyuz Sovetskikh Sotsialisticheskikh Respublik____SSSR
spacing of Bragg planes in a crystal____*d*
species (singular) ____sp.
(plural) ____spp.
specific gravity____sp gr
specific heat____sp ht
specific heat capacity____*c*
specific volume____sp vol
speleological____speleol.
square____sq
Square (in address or as part of place name) ____Sq.
standard____std
standard deviation____σ
standard error of laboratory means____s_x
standard mean ocean water____SMOW
standard state____°
standard state Gibbs free energy____$G°$
standardized normal distribution____s.n.d.
station (s) (used only with numbers) ____sta (s).
Statutes at Large____Stat. L.
Revised Statutes____Rev. Stat.
Supplement to the Revised Statutes____Supp. Rev. Stat.
steamship____SS
Stefan-Boltzmann constant____σ
steradian (solid angle) ____sr
stokes____St
strain, normal or linear____ϵ
strain, shear____γ
stratigraphic (al) ____strat.
Street (in addresses only) ____St.
stress, normal____σ
stress, shear____τ
Student's *t*-statistic____*t*
subgenus____subgen.
subset of; is contained in____$\subset$
subspecies____subsp.
sum____Σ
sum of squares____SS
sum of squares of the replication totals____T_r^2
sum of squares of the treatment totals____T_t^2
sum total of observations in a sample____*T*
summary____summ.
Superintendent____Supt.
supplement (s), supplementary____supp.
surface tension____γ or σ
symmetrical____sym
tangent____tan
tangent, hyperbolic____tanh
technic(al) ____tech.
technologic (al) ____technol.
temperature____temp
temperature, in degrees Celsius____*t*
temperature, in kelvins; absolute temperature; thermodynamic temperature____*T*
tera (prefix) ____T
Terrace (in addresses only) ____Ter.
Territory, Territories, Territorial____Terr.
tesla____T
theoretical frequency of observations____*T*
therefore____$\therefore$
thermogravimetric analysis____tga

thickness____t or d
thin-layer chromatography____tlc
third____3d
thus____sic
tilde____$\sim$
time____t
ton, metric____t
topographic (al) ____topog.
total (grand) of observations squared____G^2
Township, -s (legal land division) ____T., Tps.
trace____tr.
transformed observation____u
transmittance____T
triangle____$\triangle$
trigonometric functions, inverse circular, prefix to be added to abbreviation (for example, arccos) __arc
trinitrotoluol____TNT
tritium____T or ^3H
tritium unit____TU
triton____t
2, 3-dimercaptopropanol____BAL
ultraviolet____uv
undetermined____undet.
unified atomic mass unit____u
Union of Soviet Socialist Republics____U.S.S.R.
union or logical sum____U
unit-cell edges____a_0, b_0, and c_0
United States (adjective) ____U.S.
United States Board on Geographic Names____BGN
United States Code (with number or number and lowercase letters, such as U.S.C. 10 a-d) ____U.S.C.
United States Code Annotated____U.S.C.A.
United States Code Supplement____U.S.C. Supp.
United States Geological Survey (use abbreviation where followed by locality or collection number) ____USGS
United States National Museum (use abbreviation where followed by locality or collection number) ____USNM
United States of America____U.S.A.
universal time____u.t.
Universal Time, Coordinated____UTC
Universal Transverse Mercator____UTM
university____univ.
vacuum____vac
vapor pressure____vp
variance, statistic to estimate the variance of lognormally distributed observations____V^2
variance of linear combination q____σ_q^2
variance of lognormal distribution____β^2
variance of negative binomial distribution____k
variance of population means____σ_{μ}^2
variance of sample mean____$\sigma_{\bar{w}}^2$
variation operator, for constant x____δx
varies as____$\propto$
velocity____v or u
velocity of light (in vacuo) ____c
velocity, P-wave____v_P
velocity, S-wave____v_S
versed sine____vers
versus (legal usage) ____v.
(standard usage) ____vs.
vertical angle elevation bench mark____VABM
vinculum (above letter) ____$\overline{}$
virgule____/
viscosity, dynamic____η
viscosity, kinematic____ν
volt____V
volume, chemical and physical use____V
bibliographic use____v.
volume per volume____v/v
volume strain, bulk strain____θ
watt____W
watthour____Wh
wavelength____λ
wavenumber____σ or ν
weber____Wb
weight____wt
weight per volume____w/v
weight per weight____w/w
west____W.
wind-velocity symbol____
yard____yd
year____yr
yields____$\rightarrow$
Young's modulus of elasticity____E
zoologic (al) ____zool.

TYPING THE MANUSCRIPT

Printing technology is changing rapidly, but at present, and perhaps for some time to come, somebody at some stage of the Survey manuscript's author-to-reader journey must put the copy one letter and one space at a time into reproducible form. The transmitted copy must therefore be legible and it should be susceptible to photocopying. Black letters on white paper are ideal; dittoes and light blues are generally not acceptable for transmittal. Enough copies should be transmitted to permit reviewers and manuscript-processing offices to retain copies if desired. After transmittal the author should at all times have at hand a complete current copy to facilitate answering telephone or other queries.

So far as circumstances permit, the author should make himself easily available to the person who is typing his manuscript, and he should answer patiently the typist's tactful questions about possibly illegible handwriting and various kinds of apparent inconsistencies and errors. He must never adopt a "That's what I wrote, and that's what I meant" attitude lest he thereafter get exactly what he wrote.

The typed copy should be carefully proofed. Truly adequate proofing requires two persons, one to read aloud while the other checks silently. The two people most competent to proof any given manuscript are the author and the typist, and the author should not feel it is beneath his dignity to do so. Figures, particularly, should be meticulously proofed, and all calculations should be machine checked as well as proofed after the paper has been typed. Some reports have actually had to be reprinted because of errors in simple arithmetic that were not caught. It is a convenience to reviewers and editors if machine tapes accompany manuscript calculations.

The typed and proofed text manuscript should be transmitted flat, never folded or rolled, in a secure cover or envelope. Illustrations copy should be transmitted in one or more packages separately but at the same time as the text manuscript, and all the packages should be clearly marked as parts of a whole. Transmittal procedures and routing instructions are issued by each Division for its reports.

As a time and money saver, the Survey editorial staff has obtained permission from GPO to forward copy for long, complex tables in handwritten form. Two restrictions are imposed: (a) The copy must be neat, uncrowded, and clearly legible. Engineers' lettering is suggested, but not required, if handwritten tabular copy is forwarded; (b) the handwritten tables should consist mainly of statistical matter rather than of

reading columns. (The permission to transmit handwritten copy does not apply to those standardized tables that are prepared as camera copy by the originating Divisions and which, through long use, require no editing, retyping, or typesetting.)

The suggestions in this section apply only to typing of author's manuscripts. No part of an edited manuscript should be retyped unless the editor has requested it. An edited manuscript retyped is a manuscript that must be reedited. If the editor requests any retyping, the original edited pages should be returned with the newly typed ones.

Instructions for Typists

The instructions given below for typists apply to most Survey manuscripts that proceed through the author-to-reviewer-to-editor-to-typesetter-to-printer routine. Some instructions may not apply to certain special types of manuscripts, such as those consisting in part of computer printouts and those submitted, by prearrangement, in camera copy.

The typist who is to prepare manuscript copy for a Geological Survey report should become familiar with the format of title page, table of contents, first page, tables, and other details of a recent Survey publication of similar type. Then the typist should:

Type the report on only one side of heavy-quality letter-size paper. Leave ample margins (at least 1 inch) on all sides of each page of text, including tables. Don't crowd anything to save paper. Type the entire report double spaced, including contents list, tables, geologic sections, footnotes, well logs, quotations, captions of illustrations, references, and bibliographies; this instruction is a "must," to allow room for editorial marking and instructions to typesetter. Be sure to place sequential page numbers at the bottom of the pages.

In the "Contents," type the first-rank headings flush to the left; indent the other headings in multiples of three or more spaces, according to their rank. Capitalize only such words in the table of contents as should be capitalized in the text. Leader with hyphens to the page numbers, the numbers being those of the pages on which the headings appear in the manuscript. Place "Continued" lines at the head of every page of the table of contents, if applicable, to show the indention and relative rank of the continued items.

On the first page of text, leave at least 2 inches of space above the title (or overall title if there is one). Place the full title of the report and the author's name above the abstract.

Capitalize the first word and proper names in all headings. Indent several spaces for the beginning of paragraphs.

As far as possible, type manuscript copy so that no paragraph breaks at the bottom of the page. If the paragraph is too long for the page, the last few lines may be typed single space. If the paragraph will not

fit on a single page, type the remainder of the copy on another sheet on which nothing else is typed. Sheets of a text manuscript intended for Survey publication should not be pasted lengthwise—one of the first acts of the copy preparer at the printing plant is to cut overlong text sheets into segments that will fit on the typesetter's reading rack.

Type captions of text figures on separate sheets of paper. Center a one-line overrun; type in hanging-indention format if caption runs more than two lines. Use the figure numbers as given by the author; the editor will assign final figure numbers.

Type tables separately from text matter. Sheets may be joined, or oversize paper may be used for a table that must be wider than letter paper. Dull-finished pressure-sensitive tape, not staples or rubber cement, is used for joining sheets. Underscore for italic the heading of a table or geologic section. See that units of measure are written over columns of figures representing such units. Use "Do." for "ditto" in first and last columns, "do." elsewhere; the ditto symbol (〃) is not used in Survey style. If successive figures, symbols, or abbreviations in a column are the same, repeat them; "do." is used only in reading and standard date columns.

PROOFREADING

The number and kinds of proof an author must read vary with the custom of the publishing organization and with individual circumstances. The Survey author usually proofreads his report twice, once after it has been typed and once after it has been typeset. If the report is very "rush" and the author is not immediately available for proofreading, someone in the manuscript-processing unit of his Division or some designated alternate may read proof and then authorize the next step of the publishing process.

Proofreading is best done by two people, one reading aloud to the other. If the report is lengthy, the author and his assistant proofreader will take turns at reading aloud, as the voice of one of them begins to become weary or hoarse. If no assistant is available, it is still well for the author to read aloud to himself, because the eye alone may not spot misspellings, undesirable punctuation, or whole misplaced sentences or paragraphs.

As long as his report is in the typescript stage, the author is free to make such changes, additions, or deletions as he thinks are needed. These changes may be made in the body of the text, in the margins, or on a separate sheet of paper, as most convenient and intelligible to the typist and to editors.

Once the report has been typeset, whether the author receives galley or page proof for reading, he is expected to limit his changes to typographical errors, serious errors in fact, or deviations from the copy from which the typesetter worked; changes of wording made only to improve style will probably be disallowed. The author's changes made to correct some deficiency not previously noted in the manuscript should be marked with an "AC" or with a different-colored pencil from that used for printer's errors because the printer must bill separately for "author-correction" changes. The manuscript itself must not be marked at this stage, for it is sometimes necessary to audit cost of corrections.

Authors who find errors of fact that require "AC" corrections in their proof-stage reports are supposed to feel very embarrassed, because proof-stage corrections are expensive and time-consuming. Furthermore, every typesetting machine is equipped with gremlins who watch eagerly for a chance to incorporate new, perhaps worse, errors in reset type. However, the social stigma attached to "AC" corrections having been noted, it may be further noted that errors in a printed paper will be there a long time. The author may decide to endure a little present embarrass-

ment in order to pass on to posterity a more perfect paper. On the other hand, if he just keeps quiet, posterity may not notice the error anyway.

When the author receives the typeset proof, it will probably already have some printer's or editor's marks. These marks, which may indicate doubt, inconsistencies, or blanks to be filled, should be carefully noted and action taken as indicated.

Printed-proof corrections must be made clearly and legibly in the margin of the proof opposite the place of occurrence; the typesetter has no obligation to search the body of the text for changes.

To indicate that something should be inserted, place a caret (^) at the point on the line where the insertion should be made, and write in the margin the matter to be inserted.

To indicate that something should be taken out and not replaced by something else, draw a line through it and place the "dele mark" (ℌ), a form of "d" meaning "delete," in the margin.

If something is to be substituted for the matter deleted, mark through the matter to be replaced and write the substitute matter in the margin or on a separate sheet.

Do not run "skyrocket" marks from the place where a correction should be made to a mark or added matter written at some distant place on the margin of the proofsheet unless there is not room for the correction opposite the line to which it belongs. Do not cross one skyrocket mark with another.

Place punctuation and other marks that might be obscure if written alone to the left of a diagonal stroke, thus: ,/ ;/ -/. The diagonal stroke is used also (a) to separate one correction from the next where they are crowded in the margin and (b) to show the end of the corrections. A period to be inserted should be placed in a circle ⊙ . The space mark (#) indicates that a space such as is used between two words should be inserted at the place noted by a caret in the body of the proof.

A list of commonly used proofreader's marks and an example of their usage is reproduced from the "United States Government Printing Office Style Manual" (1973, p. 4–5).

PROOFREADER'S MARKS

⊙	Insert period	*caps.*	Caps—used in margin
⋀	Insert comma	≡	Caps—used in text
:	Insert colon	*c+sc*	Caps & small caps—used in margin
;	Insert semicolon	≡	Caps & small caps—used in text
?	Insert question mark	*l.c.*	Lowercase—used in margin
!	Insert exclamation mark	/	Used in text to show deletion or substitution
=/	Insert hyphen	*w.f.*	Wrong font
⋁	Insert apostrophe	⁀	Close up
⋁⋁	Insert quotation marks	ℓ	Delete
⊥	Insert 1-en dash	ℓ	Close up and delete
⊥	Insert 1-em dash	↻	Correct the position
#	Insert space	⊐	Move right
ld>	Insert lead	⊏	Move left
shill	Insert virgule	⊓	Move up
⋁	Superior	⊔	Move down
⋀	Inferior	‖	Aline vertically
(/)	Parentheses	=	Aline horizontally
[/]	Brackets	⊐⊏	Center horizontally
□	Indent 1 em	⊔⊓	Center vertically
□□	Indent 2 ems	⌣	Push down space
¶	Paragraph	⁀	Use ligature
no ¶	No paragraph	*eq.#*	Equalize space—used in margin
tr	Transpose [1]—used in margin	*vvv*	Equalize space—used in text
∩	Transpose [2]—used in text	*stet.*	Let it stand—used in margin
sp	Spell out	.....	Let it stand—used in text
ital	Italic—used in margin	⊗	Dirty or broken letter
———	Italic—used in text	*run over*	Carry over to next line
b.f.	Boldface—used in margin	*run back*	Carry back to preceding line
~~	Boldface—used in text	*out, see copy*	Something omitted—see copy
s.c.	Small caps—used in margin	*9/?*	Question to author to delete [3]
═══	Small caps—used in text	⋀	Caret—General indicator used to mark exact position of error in text.
rom.	Roman type		

[1] In lieu of the traditional mark "tr" used to indicate letter or number transpositions, the striking out of the incorrect letters or numbers and the placement of the correct matter in the margin of the proof is the preferred method of indicating transposition corrections. (See rule 2.75.)

[2] Corrections involving more than two characters should be marked by striking out the entire word or number and placing the correct form in the margin. This mark should be reserved to show transposition of words.

[3] The form of any query carried should be such that an answer may be given simply by crossing out the comp'ete query if a negative decision is made or the right-hand (question mark) portion to indicate an affirmative answer. (See example, p. 5.) (See rule 2.71.)

sc — TYPOGRAPHICAL ERRORS — reset 8 pt. c&sc

It does not appear that the earliest printers had any method of correcting errors before the form was on the press. The learned ~~The learned~~ correctors of the first two centuries of printing were not proofreaders in our sense; they were rather what we should term office editors. Their labors were chiefly to see that the proof corresponded to the copy, but that the printed page was correct in its latinity ~~that the words were there~~, and that the sense was right. They cared ~~but~~ little about orthography, bad letters or purely printers' errors, and when the text seemed to them wrong they consulted fresh authorities or altered it on their own responsibility. Good proofs in the modern sense, were ~~im~~possible until professional readers were employed men who had first a printer's education, and then spent many years in the correction of proof. The orthography of English, which for the past century has undergone little change, was very fluctuating until after the publication of Johnson's Dictionary, and capitals, which have been used with considerable regularity for the past 80 years, were previously used on the miss or hit plan. The approach to regularity, so far as we have, may be attributed to the growth of a class of professional proofreaders, and it is to them that we owe the correctness of modern printing. More errors have been found in the Bible than in any other one work. For many generations it was frequently the case that Bibles were brought out stealthily, from fear of governmental interference. They were frequently printed from imperfect texts, and were often modified to meet the views of those who published them. The story is related that a certain woman in Germany, ~~who was~~ the wife of a Printer, ~~and~~ had become disgusted with the continual assertions of the *superiority* of man over woman which she had heard, hurried into the composing room while her husband was at supper and altered a sentence in the Bible, which he was printing, so that it read Narr instead of Herr, thus making the verse read "And he shall be thy fool" instead of "and he shall be thy lord." The word not was omitted by Barker, the king's printer in England in 1632, in printing the seventh commandment. He was fined £3000 on this account.

8/?

NOTE.—The system of marking proofs can be made easier by the use of an imaginary vertical line through the center of the type area. The placement of corrections in the left-hand margin for those errors found in the left-hand portion of the proof and in the right-hand margin for right-side errors prevents overcrowding of marks and facilitates corrections. (See also rule 2.74.)

REPORTS ON WATER RESOURCES

By the WATER RESOURCES DIVISION STAFF

Reports on water resources may involve geology, geophysics, surface- and ground-water hydrology, and various aspects of water quality, and they may present basic research, methods and techniques, or statistical data. In terms of project objectives, reports can be broadly categorized as (a) water-resource appraisal, (b) research, (c) critical problems, and (d) basic data.

CHOOSING THE TYPE OF REPORT

Most water-resource studies in the past have been supply oriented, but as the resource has become more fully developed, the studies are being directed more toward resource management. The purpose of a report should be carefully identified and meticulously stated at project conception. Format and outlet for publication should also be determined early: Is a Water-Supply Paper or a Professional Paper more appropriate? Or should the technical information be presented in multiple publications, such as a planning bulletin for the State cooperator, a pictorial pamphlet for the general public, and a journal article for the scientific community? Program planning frequently governs the intensity of investigation and scope of the report. A brief hydrologic evaluation of an area may be presented as a reconnaissance report, whereas a detailed study may require exhaustive treatment.

RESOURCE-APPRAISAL REPORTS

Although no general outline is suitable for all reports on water resources, appraisal reports are the most typical and they usually contain the following parts: (a) a systematic treatment of essential components that relate to water-resource availability; these components often include a description of the geologic formations and their water-bearing properties and water quality, precipitation, streamflow, recharge, discharge, limitations on development of surface water and ground water, boundary conditions that control availability and quality of water, and the cause-and-effect relations in hydrologic systems; (b) detailed descriptions of subareas, if the overall study area is large or hydrologically

complex, such as discussion of the importance of flow-system boundaries in relation to the regional hydrology and water problems of the area as a whole; and (c) summary or conclusions that emphasize significant results of the investigation.

The body of reports will differ considerably according to the nature of the area or problem to be studied. As a rule, geographic, geologic, and hydrologic descriptions should not be more elaborate than necessary to accomplish objectives. Some statement of pertinent hydrologic principles is warranted, but not extensive exposition. Similarly, a report should contain a glossary if technical terms are numerous. Valuable geologic or hydrologic results or new techniques or methods may be developed during an investigation; these may deserve publication elsewhere if their details are not essential to the report. Judgment and expedience determine whether such material should be included in the main report or presented in a separate technical journal or publication. if the area has a stratigraphic section comprising more than a few units, the general description should include a table of the geologic formations that contains a column for brief statements concerning the water-bearing properties of, and the quality of water in, each formation.

Insofar as the information is essential to discussion of the ground-water, water-quality, and surface-water conditions, the description of stratigraphic units should include information usually given in geologic reports, such as distribution, thickness, lithologic features, age, and stratigraphic relations. Mineral assemblages in stratigraphic units usually have a pronounced effect on surface-water and ground-water quality and this effect should be described. Detailed geologic data, such as lists of fossils identified, may be included but generally will be published in a separate paper. Systematic descriptions should include (a) detailed information on the water-bearing properties of the formations and on the head and quality of the water, and (b) pertinent data on the performance of typical wells. The result of pumping tests and other types of aquifer tests used in determining transmissivity and storage can properly be included in the systematic descriptions or tables, provided the report includes sufficient detail to enable the reader to evaluate the author's analysis of pumping-test results. Related data concerning such features as particle-size distribution, porosity, moisture equivalent, and permeability can be presented in systematic descriptions or in tables, usually at the end of the report.

Discussions of surface water in areal reports commonly contain evaluations of flow availability at key points in the stream system and descriptions of the relation of "gaining" and "losing" reaches to ground-water conditions. The quantitative relation between surface-water and ground-water supplies often is a critical control in evaluating the total water resource or the cause-and-effect relations and problems resulting from large ground-water withdrawals or stream diversions. Where streams interact with ground-water systems, one source of supply or water problems cannot be realistically analyzed without consideration

of the other. Other types of reports on surface water include descriptions of unusual hydrologic events, such as floods and droughts, the hydrology of specific areas, and general hydrologic or hydraulic principles.

In referring to records collected at a stream-gaging station, authors should give the station name in its entirety, except that the State name may be omitted if it is obvious from the context. Station names contain "at" or "near" or a similar term; these words are an integral part of the station name and should not be used loosely.

In reports dealing with surface-water supply, the 12-month period ending September 30 each year is termed the "water year"; for example, the year that ended September 30, 1975, was the "1975 water year."

Discussions of water quality related to use must be based on understanding of relevant criteria and standards. Restrictive governmental standards apply principally to water used for domestic supply, water-contact recreation, and fish and shellfish cultivation. Concentrations lethal or hazardous to animals are cited when they are known. Virtually all uses are thoroughly discussed in the U.S. Environmental Protection Agency report "Water Quality Criteria, 1972." Standards for water used for domestic supplies are given in "Primary Drinking Water Standards" (U.S. Environmental Protection Agency, 1975). Authors should be aware also that the goal of the Federal Water Pollution Control Act Amendment of 1972 (PL–92–500) is that the discharge of pollutants into the navigable waters be eliminated by 1985. Biological, biochemical, and radiochemical standards and limits vary for different uses and for different receiving waters. These standards too should be discussed in light of constraints applicable to the study area rather than from broad generalizations. The author is obligated to search out and use criteria and standards currently applicable. Hem (1970) presented a useful guide in the study and interpretation of the chemical characteristics of natural water. Many water-resource reports contain descriptions of the water quality, for example: Iorns and others (1964; 1965), Weeks and others (1974), Bolke and Waddell (1975), Hughes (1975), and Winograd and Thordarson (1975). The author should describe the geochemical properties of the consolidated and unconsolidated rocks through which or over which the water flows and should interpret the resultant changes in water quality. Tabulations of data must be accurate and as nearly uniform and consistent as possible to simplify interpretation by others.

If fluvial sedimentation is considered in the areal report, the discussion will generally define some aspect of erosion, transportation, or deposition. Areal investigations frequently require collection of sufficient data at hydrologic stations to compute sediment-yield rates, which are expressed in weight of dry sediment per unit area per unit of time, for example, tons per square mile per year or its metric equivalent. Sediment-transport rates may also be used to predict rates of deposition in a channel system or a reservoir by converting the weight of dry sedi-

ment to volume, such as acre-feet or cubic meters, on the basis of the specific gravity and particle-size distribution of the sediment in transport and the compaction characteristics of the sediment. Authors should report in detail the equipment and methods used in both field and laboratory measurements of sedimentation; "U.S. Geological Survey Techniques of Water-Resources Investigations," book 3, chapters C1 and C2, (Guy, 1970; Guy and Norman, 1970) should be used as principal references in describing these procedures. Precise and consistent terminology is necessary in reports on sedimentation; "siltation," for instance, is not a synonym for "deposition." Terminology with respect to modes of sediment transport and the mechanics of channel behavior should generally conform to that in Manual 54 of the American Society of Civil Engineers (Vanoni, 1975), but its specific application should be defined in the context of the report.

Detailed descriptions of subareas in water-resource reports may aid greatly in applying the facts and conclusions of the report to the determination of conditions in specific localities. Much skill is required in preparing material on each subarea to avoid repetition of general statements and yet to describe adequately the conditions in all parts of each subarea. It is appropriate here to apply the data collected to appraise the water resources or to evaluate hydrologic problems in the subarea. These problems may include different plans of resource development, mutual interference of pumped wells under different spacings and operating schedules, changes in stream regimen resulting from upstream diversions and development, changes in sediment transport caused by changes in land-use patterns, and changes in quality and temperature of water that may accompany its utilization. Carefully selected well, streamflow, sediment, and water-quality data can be given in the sections on subareas, either in the text or in accompaning tables. Generally, data given in the tables should not be repeated in the text, although representative data may be cited to bring out specific points. Likewise, well sections given in detail in graphic form should generally not be duplicated in tabular form. Bulk water-resources data related to projects are usually released in open-file or Water-Resources Investigations reports because publication cost is high. Publication of this type of material as appendixes to the areal report, as a rule, is not acceptable. These limitations point out the need for careful design of data collection during the course of a project. Projects and reports can become hopelessly delayed by the time taken in collecting all available data in a highly developed area, much of which may be superfluous to the study objectives.

Increasingly, emphasis is on quantitative definition of the regional flow system and its controlling conditions, or hydrologically significant subareas within it, rather than on detailed nonquantitative descriptions of type areas or local sites. For information on conditions at a specific site, the reader will probably refer not to a locale description in the text but to information in tables and on maps and graphs. Using this

information, he is able to appraise the prospects of obtaining water in the desired quantity and of necessary chemical quality at any given site. Regional planners find many desirable features in the pictorial-style format, such as the reports by Cohen and others (1968, 1970). By using numerous maps, sections, and graphs, the author of this type of report can show pertinent hydrologic conditions at nearly any desired location and can make his report a most useful reference for both lay and technical readers.

Research Reports

The research report cannot be defined easily for author guidance because of the wide variety of material represented. The project description, however, is commonly more flexible than that for an areal study, because research by its very nature must have the option of the multiple-hypothesis approach. An exhaustive literature review is usually made in research studies.

The author can communicate a lengthy, complicated mathematical treatment to a much broader technical audience by an accompanying narrative that explains the import of the mathematical sequences presented. Similarly, many complicated relationships can be clarified by carefully designed graphs or diagrams that complement the author's exposition.

Significant figures, whether they are in an areal or in a research report, require careful consideration by the author and should be evaluated for the accuracy he needs to convey. Even the most carefully measured flow of water is seldom within 2 percent accuracy; the value given in the report should be rounded accordingly. Qualitative estimates of regional hydrologic characteristics, such as ground water in storage, may be subject to an error of 25 percent or more. These estimates should certainly be rounded to no more than two significant figures and preferably to one significant figure. See pages 197–202 for further discussion of significant figures.

Reports on Critical Problems

In recent years many water-resource reports have focused on selected types of problems of national interest rather than on the general hydrologic conditions of a selected area.

Reports on critical problems are usually generated by a specific water problem that requires a solution but if, as a part of the solution, new principles are developed that could have wide application in other areas or in other phases of hydrology, the research aspect of the investigation may be included in the critical-problem report or published as a separate research paper. The theory on induced infiltration in the

Louisville, Ky., area is an example of such a development (Rorabaugh, 1956, p. 117–125).

Basic-Data Reports

Water data are the raw materials used by scientists and engineers for determining the availability, quality, and adequacy of the water resource and for the design, development, and management of major water projects. A significant part of the effort of the Water Resources Division is devoted to the collection, compilation, and timely publication of water data. In recent years, water data have been released in the series of Geological Survey reports titled, "Water-Data Report for [the appropriate State or group of States]." These data were formerly published in Water-Supply Paper series titled "Surface-Water Supply of the United States" (1900–70), "Quality of Surface Waters of the United States" (1941–70), and "Ground-Water Levels in the United States" (1940–74). These reports contain tabulations of discharge (streamflow), reservoir storage, chemical and biological analyses, sediment determinations, water temperature, water levels, and other related information.

As the number of data-collection sites increases and the variety of types of data collected expands, the use of electronic computers and data banks also grows. Computers, however, have not yet eliminated the need for water-resource data reports in book form. Not many users have access to the appropriate data banks. Publication of data reports serves other necessary purposes: The printed copy provides an archival capability for easy reference, and it releases large quantities of data to a broad audience, at low cost.

Data presentation

Basic-data reporting of the Geological Survey is usually one of two types. The first is specifically designed to make available to every user, without analyses, interpretations, or conclusions, all information collected and processed. These are the data published in the annual series of State reports (see above). The second type presents supporting data in, or released separately as part of, a special or analytical project report. In such a report the data used for exposition are specifically selected to amplify the technical findings of the investigation and to elucidate the basis for decisions or conclusions reached in the technical report.

The introductory pages in the annual series of reports follow a standard format which describes the data-collection and processing program, identifies cooperating agencies, defines technical terms used, cites reports containing data for previous years, advises of supplemen-

tary information that can be obtained from office files, and describes any special-data networks and programs. An annual report also presents the hydrologic conditions during the water year. Data reports prepared as part of a project do not generally follow a standard format because the type of data presented differs in accordance with the purpose and scope of the project, usually has a short time span and high areal density, and rarely is part of the basic long-term hydrologic network.

As much of the information as possible is given in tabular form on duplicated printouts from computer storage. Aside from the obvious advantage of giving maximum information in minimum space and eliminating much tedious, repetitive typing, this method provides an opportunity for visual check of figures stored in the computer banks. Tabulated streamflow data generally include daily mean discharges; monthly and yearly summaries of minimum, mean, and maximum daily values; total volumes; and sometimes unit runoff. Reservoir data are often given as daily contents, usually at a specific time. Ground-water levels are usually given at 5-day or less-frequent intervals. Water-quality data include a wide variety of information concerning concentrations of inorganic and organic compounds and biological and physical characteristics.

Supplemental information should accompany the data in tables: (a) the site at which the data are collected should be identified; the simplest and briefest way is by latitude and longitude. The reports should give not only that information necessary for plotting the site on a map, but also enough additional information to find the site in the field by commonly available roads and local landmarks. Changes in the site during the period of data collection should be identified. (b) Political subdivisions and an indication of where the site fits into the general drainage pattern or geologic setting should also be described. (c) The types of information available at a site, together with the time span of each type, should be given. For instance, streamflow or water-level data may be available for a moderately long period, and data for recorded extremes, such as floods or droughts, may be available for an even longer period. Water-quality data, on the other hand, may be available only for short periods. (d) Instrumentation at the site should be described to assist the user in analyzing the completeness and reliability of the data. Recording instruments provide detailed records of measurements and thus are more useful in interpreting the data than is information collected intermittently. (e) Conditions of streamflow or water level at the site and the use to be made of the data determine the measurement frequency.

Data reports, in addition to documenting the water information, should be flexible in content. Their scope should be reviewed periodically to determine whether the information answers the changing data needs of the Nation. Two general examples of the presentation of well descriptions and water-level data are shown below.

SAMPLE TABLE F.—*Records of boreholes screened in Gwandu Formation, Sokoto Basin*

Location: Name of village in or near which corresponding borehole is located.
Borehole: Serial numbers are assigned by Geological Survey of Nigeria (GSN) to all boreholes in northern Nigeria.
Approximate elevation: Measured by aneroid barometer from nearby Federal Surveys bench marks.
Casing: American Petroleum Institute line pipe (mild steel casing) used to case most boreholes.
Screen: Most screens are of Johnson Everdur. Setting indicates top and bottom of borehole screen.
Static pressure head: Pressure head at time borehole was completed, in feet above (+) or below (—) land surface.
Yield: At time borehole was drilled. F, natural flow; P, turbine pump; A, airlift pump.
Remarks: M, borehole drilled by Ministry of Works for public water supply; C, chemical analysis in table 7; T, flow or pumping test carried out at borehole; A, abandoned test hole, casing pulled and hole plugged; B, borehole drilled by Balakhany (Overseas), Ltd.; O, observation borehole drilled by Balakhany (Overseas), Ltd., for the Geological Survey of Nigeria; F, Foxboro pressure recorder installed; S, Stevens water-stage recorder installed.

Location	Borehole	Approximate elevation (feet above sea level)	Date completed	Casing diameter (inches)	Total depth (feet below land surface)	Screen			Static pressure head	Yield (gallons per hour)	Drawdown (feet)	Remarks
						Diameter (inches)	Setting (feet below land surface)	Slot opening (thousandths of an inch)				
Birnin Kebbi	GSN 2480	674	9–10–61	6	250	6	170–230	----------	+13	2,200 F 9,000 P	--------	M
Rafin Kubu	2499	787	8– 8–64	3	465	1¾	436–451	10	+39	2,000 F	0.55	B, C, T
Tapkin Kwato	2500	780	9– 2–64	3	590	1¾	560–575	10	+52	3,000 F	--------	B
Bacaka	2674	803	10– 9–64	2½	1,005	1¾	979–994	10	+40	1,200 F	21	B, C, T
Balle	3051	750	5– 3–63	2½	279	1¾	253–269	10	+51	1,200 F	--------	C, O
Do	3052	750	5–29–63	2½	398	--------	350–393	Open hole	+70	12,000 F	--------	A, O
Do	3054	782	9– 9–63	6	520	3¾	514–519	15	+46	7,000 F	.7	C, T, O
Do	3055	782	9–23–63	6	376	3¾	367–372	15	+46	5,000 F	7	C, F, T, O
Kurdula	3056	760	10–13–63	2½	858	1¾	820–835	15	+83	3,000 F	--------	C, F, O, T
Do	3057	760	10–31–63	6⅝	255	1¾	237–255	15	+40	250 A	--------	O
Tangaza	3058	845	3– 9–64	2½	302	1¾	189–199	10	+2	90 F 2,100 A	--------	A, O
Do	3059	847	3–19–64	6⅜, 4, 2½	219	1¾	172–197	10	0	6,000 P	46	C, S, T, O
Do	3060	847	3–29–64	3	177	1¾	175–185	10	0	1,900 A	--------	O
Yeidu	3061	785	5– 5–64	2½	660	1¾	520–530	10	−27	1,500 A	48	A, O
Do	3062	745	5–16–64	3	540	1¾	520–530	10	+13	1,200 F 2,000 A	--------	O
Do	3063	744	5–28–64	6, 4, 2½	540	3½	508–523	10	+15	1,200 F 4,200 A	------- 48	C, F, T, O

SAMPLE TABLE G.—*Well descriptions and water-level measurements*

[Water levels are reported in feet below land-surface datum unless otherwise indicated. Barometric leveling is used in referencing land-surface datum]

Adams County

43758N0894900.1. Local number Ad-17/6/8-2. Wisconsin Conservation Dept. Jetted observation water-table well in sand of Pleistocene age, diam 2 in, depth 21 ft, cased to 19, well point 19–21. Lsd 955 ft above msl. MP top of casing, 1.70 ft above lsd. Highest water level 12.58 below lsd, July 11, 1960; lowest 18.05 below lsd, Apr. 6, 1959. Records available: 1952–70. Well destroyed; measurement discontinued. Replaced by well AD-17/6/8-76.

Date	Water level	Date	Water level	Date	Water level	Date	Water level
Jan. 30, 1967	16.09	Dec. 26, 1967	15.99	Nov. 25, 1968	14.95	Oct. 27, 1969	14.66
Feb. 27	16.43	Jan. 29, 1968	16.21	Dec. 31	15.26	Nov. 24	14.82
Mar. 27	16.74	Feb. 26	16.39	Jan. 27, 1969	15.54	Dec. 29	15.22
Apr. 3	16.71	Mar. 25	16.62	Feb. 24	15.75	Jan. 26, 1970	15.56
May 1	16.34	Apr. 15	16.70	Mar. 24	15.90	Feb. 23	15.93
June 6	15.98	May 13	16.58	Apr. 7	15.74	Mar. 30	16.20
July 3	15.60	June 3	16.27	May 5	15.06	Apr. 20	16.25
Aug. 28	15.50	July 1	15.98	June 2	14.53	May 4	16.21
Sept. 25	15.61	Aug. 5	15.36	July 7	14.07	June 1	15.99
Oct. 30	15.76	Sept. 9	15.25	Aug. 25	14.07	July 6	15.28
Nov. 27	15.85	Oct. 7	14.96	Sept. 29	14.44	Aug. 10	15.25

Real-time data

The development of the satellite-relay program, the increasing availability of computer-terminal outlets, and the land-line systems of transmitting data from field-observation sites to computers and to field offices enable users to obtain current records in an extremely short time. Although printouts can be assembled for publication, they quickly become historic because of normal publication delay. A system incorporating either a satellite relay or a land-time system provides data indicating conditions at the station at the time of inquiry. Data entering the computer are almost immediately available to users through terminal networks and also become available for future compilation and interpretation. Because communication technology is changing rapidly, the manner in which data are collected and released and data reports are prepared and disseminated is expected to change significantly in the future. The general guidelines for handling water-resources data, as briefly described in this section, therefore, may also become largely outdated in a few years.

WATER-RESOURCE TERMS

Some water-resource terms have been used with different meanings in water reports so frequently that it seems advisable to call attention to them. As Meinzer stated (1923, p. 2), a scientific term is a symbol that represents a scientific concept. The term has the same significance as the definition of the concept; it is neither more nor less precise. However, there should be general agreement on the meaning of the term. The "Glossary of Geology" of Gary and others (1972) contains many

water-resource terms. Other references on hydrologic terminology include Langbein and Iseri (1960), largely for surface-water terms; Meinzer (1923), Lohman (1972), and Lohman and others (1972) for ground-water terms; Poland and others (1972) for terms related to mechanics of aquifers and land subsidence; the "U.S. Geological Survey Techniques of Water-Resources Investigations" series for water-quality terms; Betts and others (1962) for terms pertaining to hydraulics; and Vanoni (1975) for sedimentation terms.

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MINERAL RESERVES AND RESOURCES

By Donald A. Brobst

Accepted and acceptable definitions of mineral reserves and resources generally are not included in standard dictionaries. The definitions commonly vary with time and the perspective of individual authors, and they tend to differ with the kind of commodity described. Reserves and resources of metallic ore deposits, liquid or gaseous fuels, coal and water each may be discussed in quite different terms. Some of the terms have gained wide acceptance, although their use by different authors commonly has been marked by a vagueness that makes precise comparison of the data difficult. More uniform use of reserve and resource terminology is critical to better communication on this subject.

To meet growing needs, McKelvey (1972) proposed a unified terminology for mineral resources that was modified by Brobst and Pratt (1973, p. 1–8). In 1974, the staffs of the Geological Survey and the Bureau of Mines further altered the earlier proposals and jointly adopted the mineral-resource classification shown in figure 4 (U.S. Bureau of Mines and U.S. Geological Survey, 1976a). This classification is expected to be applicable to all mineral commodities; its use in reports is urged, although some other special terms may be adopted to deal with specific problems peculiar to certain commodities, such as oil, gas, and coal.

The distinction between **reserves** and **resources** is based on current geologic and economic factors. Thus, total mineral resources are classified in terms of both economic feasibility and the degree of assurance of their occurrence (fig. 4). Total resources also are divided into two major fields, identified and undiscovered resources, which in turn are subdivided. The definitions of the reserve and resource terms below are quoted or paraphrased from U.S. Bureau of Mines and U.S. Geological Survey (1976a, b).

Resource: A concentration of naturally occurring solid, liquid, or gaseous materials in or on the earth's crust in such form that economic extraction of a commodity is currently or potentially feasible.

Identified resources: Specific bodies of mineral-bearing material whose location, quality, and quantity are known from geologic evidence supported by engineering measurements with respect to the demonstrated category.

Undiscovered resources: Unspecified bodies of mineral-bearing material whose existence is surmised on the basis of broad geologic knowledge and theory.

Reserve: That portion of the identified resource from which a usable mineral or energy commodity can be economically and legally extracted at the time of determination. The term **ore** is also used for reserves of some minerals.

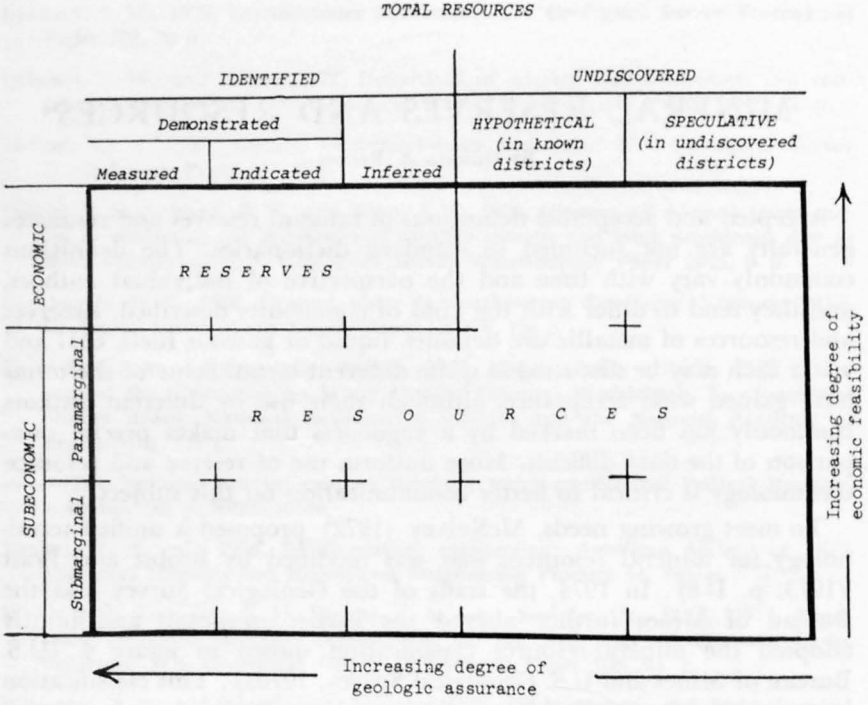

FIGURE 4.—Classification of Mineral Resources. From U.S. Bureau of Mines and U.S. Geological Survey (1967a, p. A2).

The following definitions for "measured," "indicated," and "inferred" are applicable to both identified economic resources (that is, reserves) and identified-subeconomic resources.

Measured: Material whose quality and quantity have been estimated, within a margin of error of less than 20 percent, from analyses and measurements from closely spaced and geologically well-known sample sites.

Indicated: Material whose quality and quantity have been estimated partly from sample analyses and measurements and partly from reasonable geologic projections.

Demonstrated: A collective term for the sum of materials in both measured and indicated resources.

Inferred: Material in unexplored but identified deposits whose quality and size have been estimated on the basis of geologic evidence and projection.

Identified-subeconomic resources: Known deposits not now economically minable.

Paramarginal: The portion of subeconomic resources that (a) is almost economically producible or (b) is not commercially available solely because of legal or political circumstances.

Submarginal: The portion of subeconomic resources which would require a substantially higher price (more than 1.5 times the price at the time of determination) or a major cost-reducing advance in technology to become economic.

Hypothetical resources: Undiscovered materials that may reasonably be expected to exist in a known mining district under known geologic conditions. Explora-

tion that confirms their existence and reveals quantity and quality will permit their reclassification as a reserve or identified-subeconomic resource.

Speculative resources: Undiscovered materials that may occur either in known types of deposits in a favorable geologic setting where no dicoveries have been made or in as-yet-unknown types of deposits that remain to be recognized. Exploration that confirms their existence and reveals quantity and quality will permit their reclassification as reserves or identified-subeconomic resources.

The terms "proved," "probable," and "possible" (used by industry for economic evaluations of ore in specific deposits or districts) commonly have been used loosely and interchangeably with the terms "measured," "indicated," or "inferred" (used by the Department of the Interior mainly for regional or national estimates). "Proved" and "measured" are essentially synonymous. "Probable" and "possible," however, are not synonymous with "indicated" and "inferred." "Probable" and "possible" describe estimates of partly sampled deposits. In some definitions, for example, "probable" is used to describe deposits sampled on two or three sides and "possible" for deposits sampled only on one side; in the Bureau of Mines/Geological Survey definitions, both types of deposits would be described by the term "indicated."

Except in rare instances, the author's estimates of reserves and resources for a district or area should be presented in such a way as to conceal the figures for individual properties. Quotation of published estimates, however, is permissible so long as they are properly ascribed.

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STRATIGRAPHIC NOMENCLATURE AND DESCRIPTION

By MARJORIE E. MACLACHLAN and GEORGE V. COHEE

The rocks of the United States are classified by means of a complex scheme. Most of the time terms that are applied (for example, Cretaceous) were first defined and used by European geologists and have since been accepted by geologists of most other parts of the world. However, as parts of the United States were mapped geologically, it became common practice to also apply local names to the smaller divisions of rocks recognized in individual study areas. Lithology, rather than faunal assemblages, is the basis of this local classification. The principal reason for using lithologic divisions is to aid the field geologist in recognizing and mapping the units. These lithologic divisions are called rock-stratigraphic units by the American Commission on Stratigraphic Nomenclature (1970, p. 5) or geologic names by many geologists in the United States (Gary and others, 1972, p. 292); lithostratigraphic units, much used outside the United States, are the division terms preferred by the International Subcommission on Stratigraphic Classification (1976, p. 31). Some rock-stratigraphic units may also be faunal units because of accident of selection of the boundary between two lithologies. Uncertainties in interpretation of the original definition of a local lithologic unit, or of its correlation with units nearby or many kilometers away, have resulted in a large number of locally named units, and their number increases steadily each year.

Because the U.S. Geological Survey is officially charged with examination of various aspects of geology throughout the United States, all its publications must adhere to some broadly uniform procedures in dealing with the nomenclature and classification of local rock units. The responsibility for this uniformity is delegated to a group of Survey geologists who are chosen for their experience and knowledge in the science; the group is called the Geologic Names Committee (GNC, *or* the Committee). Except for papers intended for open file and those on astrogeology, every manuscript that is written by a Survey author and that contains stratigraphic names is read and approved by a member of the staff of GNC before its publication is authorized by the Director.

Geologic Names Committee

The Geologic Names Committee was first organized on February 17, 1899, to consider all names of geologic formations or other divisions of rock classifications with a view of determining whether they comply with the rules of nomenclature adopted for the Survey publications and to recommend such action as might be advisable in any individual case to secure unity of nomenclature under the rules.

Members of the Committee are appointed by the Chief Geologist and are responsible to him through authority delegated by the Director. In addition to the chairman, stationed at the Geological Survey's National Center in Reston, Va., and a secretary (chosen from the review staff at the National Center), the Committee currently consists of 10 geologists as regular members (four in Reston, Va., three in Denver, Colo., and three in Menlo Park, Calif.) supported by (a) advisory specialists, (b) the Geologic Names Review Staff, and (c) the Lexicon of Geologic Names Staff. In addition to an office in Reston, the review staff maintains two field offices, one in Denver and one in Menlo Park. The lexicon staff maintains one office, in Reston.

The Geologic Names Committee is responsible for defining and recommending policy and rules governing stratigraphic nomenclature for the entire Geological Survey, subject to guidance and approval by the Chief Geologist. Through its review staff, it is responsible for the technical review of domestic stratigraphic nomenclature and classification in all manuscripts and maps originating in the U.S. Geological Survey, whether they are to be published by the Survey or by an outside organization and whether they result in whole or in part from the official work of Geological Survey members. Stratigraphic classification used by Survey authors in reports dealing with the geology of foreign countries is reviewed only for consistency within each report.

The Geologic Names Committee is not responsible for defining and recommending policy and rules governing stratigraphic nomenclature, in Survey manuscripts, for bodies other than the Earth. Such geologic names are considered to be informal; naming, cataloging, and coordinating astrogeologic units, as well as review of Survey manuscripts that name such units, are handled by the Branch of Astrogeologic Studies in Flagstaff, Ariz.

The basis of the Committee's consideration is the "Code of Stratigraphic Nomenclature" (the Code), written by the American Commission on Stratigraphic Nomenclature (ACSN). The ACSN currently has more than 20 members chosen from eight geological societies and State and Federal surveys in North America (American Association of Petroleum Geologists, Geological Society of America, Geological Survey of Canada, U.S. Geological Survey, American Association of State Geologists, Asociación Mexicana de Geólogos Petroleros, Sociedad Geológica Mexicana, and Instituto de Geología de la Universidad

Nacional Autónoma de México). Several editions of the Code have been printed since it was first prepared in 1933; the most recent edition appeared in 1970 and is for sale by the American Association of Petroleum Geologists, Box 979, Tulsa, OK 74101. Amendments and additions to the Code are proposed from time to time. Depending on the subject matter, they are published as ACSN Notes either in the "American Association of Petroleum Geologists Bulletin" (see, for instance, Oriel, 1975, p. 134–135) or in the "Geological Society of America Bulletin." Before the proposed changes are adopted by the Commission for inclusion in the Code, comments and discussions are invited from the geologic profession.

When major departures from official classification and nomenclature are proposed in manuscripts and are brought before the full Committee for consideration, specialists may be invited by the chairman to act as temporary members of the Geologic Names Committee.

The classification and nomenclature of rock units in manuscripts embodying the results of cooperative investigations with State geological surveys or other outside organizations accord with the official classification and nomenclature unless such manuscripts are to be published by the cooperating organization. Subject to approval of the Director, the author may use the classification of the cooperating organization, with an appropriate statement of explanation.

The Committee does not pass judgment on the validity or use of any name outside the publications of the U.S. Geological Survey. However, its records of stratigraphic names used by Survey and non-Survey geologists are available for reference at all times to all geologists; they may seek advice in person or by correspondence. If a geologist, either Survey or non-Survey, expresses his intention to use a geographic name that has not been previously applied to a rock-stratigraphic unit, a record can be made to reserve the name so that others who may inquire about the name can be informed of the first author's intention.

In reviewing manuscripts, review staff members depend on a file of annotated records, on the framework of policy and objectives as set forth by the Committee and its chairman, and on the "Code of Stratigraphic Nomenclature." Each staff member is expected to recognize significant departures from these guides and to bring them to the attention of the chairman of the Committee and to the local Committee members that they may attempt expeditous resolution of a problem at a local level. When such problems are not resolvable locally, the full Committee meets to consider whether the departures should be adopted as new official usage, approved for use in a particular manuscript without prejudice to official usage, or rejected.

The annotated records in the review staff offices are maintained as a file separate from the one maintained by the lexicon staff. The review staff file provides an accurate, timely record of stratigraphic names as used by Survey geologists, and this record reflects official acceptance by the Survey.

Through its lexicon staff, the Geologic Names Committee has for many years maintained a separate file that contains the systematic records of names of stratigraphic units in the United States as they have been used in all the published geologic literature of the United States. However, "Publication in abstracts, guidebooks, microfilms * * * is not a valid publication" (art. 3 of the Code), and no records of such usage are kept. (See p. 146, 147 for restriction on use of new names in open-file reports.)

Lexicon staff members are responsible for the compilation and recording of the published literature. Their file on each stratigraphic unit includes up-to-date information on its type locality, lithology, thickness, age assignment, and history of usage. Copies of this file are kept at the National Center and in the review staff offices in Denver and Menlo Park.

Information compiled for this file prior to 1967 is available in the following publications: Wilmarth (1938), Wilson and others (1957; 1959), Keroher and others (1966), and Keroher (1970).

Conformance to the Code and Stratigraphic Change

Accuracy and clarity are the two main objectives in all written and graphic presentation of stratigraphic data. A common initial procedure followed by a review staff member when a stratigraphic report is turned in for review is to disassemble it and place the geologic-map explanation and the stratigraphic chart alongside the geology section of the text. As the geology section is read, it can easily be compared with the other two parts. An assessment can be made at this time concerning stratigraphic changes and conformance with the Code. The reviewer then returns to the abstract and reads the report in sequence. The author may follow the same procedure as a double check before he turns the report in for review.

The official nomenclature file can be updated, modified, or augmented whenever a report that adequately explains the reasons for a stratigraphic change is submitted for publication. Obviously, the changes added to the official Survey file of annotated records are those recommended by Survey authors on the basis of their work. Because the Survey adopts a uniform nomenclature for any one area, it is advisable for the person planning to make the change to discuss his proposals with a review staff member and with his peers, especially those working near the report area, before the report is completed.

A review staff member will carefully read comments by technical reviewers of all major stratigraphic reports. Inattention to previous and current work of others in the author's Division or in other Divisions may impede the progress of a report.

The present Code (1970) includes classification schemes for (a) rock-stratigraphic, (b) soil-stratigraphic, (c) biostratigraphic, (d) time-

stratigraphic, (e) geologic-time, and (f) geologic-climate units. The primary responsibility of a review staff member is to ensure the use of formal (which means "defined as explained in the Code, art. 4–17") names of rock-stratigraphic units. Biostratigraphic units are not part of the review staff's responsibility; such units are checked by specialists in the Survey's Branch of Paleontology and Stratigraphy.

Study of the "Listing of Nomenclatural Changes" from Cohee and Wright (1975), particularly the "Revision and reference" columns (p. A3–A49) will acquaint the prospective author with the types of stratigraphic changes that are added to the official Survey records. They may be categorized as (a) new name defined and adopted, (b) previously defined name to be adopted, (c) change in age designation, (d) abandoned name, (e) change in lithologic designation, (f) stratigraphic redefinition, (g) assignment to another stratigraphic unit, (h) change in stratigraphic rank, (i) geographic extension or restriction, and (j) reinstatement of abandoned name. Some of the categories require more justification than others. Publication of the information is mandatory, and the first report to use the information must explain the change or changes. An author should not discuss, in print, stratigraphic changes that he or one of his peers plans to make at some time in the future. Since the early 1960's, more than 7,000 changes and additions have been made to the official Survey records. No one publication can possibly keep an author up-to-date; therefore, he must be certain that he has the most recent information on the rock-stratigraphic units in his study area.

The published lexicon volumes should not be quoted as the authority in stratigraphic discussions. Reference should be made to the original article upon which the data in the lexicon are based.

New names

Survey authors planning to define a new rock-stratigraphic unit should read the appropriate articles of the Code that list the requirements for new names. All formal geologic names are binomial. The first part is a geographic name. It should be the name of a river, town, or other natural or artificial feature at or near the place where the unit is typically developed. In selecting the geographic name for a new unit, reference should be made to the established geographic names on Survey topographic maps.

An author should send to the National Center, the Denver, or the Menlo Park review staff office, at the earliest possible date, a list of the geographic names and the areas for which the new stratigraphic names are to be proposed. The names will be checked against the lexicon, official Survey, and reserved-name files and, if the names are not preoccupied, they will be reserved. If the names are preoccupied, the author has an opportunity to select other names before the report is complete.

When new names are to be established for rock-stratigraphic units in areas where geographic features have not been named, application to establish the new geographic name should be made through the author's local Division reports unit. Application forms and instructions for proposing new geographic names are supplied to the reports units by the U.S. Board on Geographic Names. Proposals for new geographic names should be made by the author at an early stage in the preparation of a report.

The report in which the new name is defined should contain:

1. A statement of intent such as, "This unit is here named * * * "
2. Name of the geographic feature from which the name was taken
3. Specific designation and location of a type section, locality, or area
4. Description of the upper and lower contacts, the lithology, and the areal extent of the unit
5. The age and correlation of the unit

If an author believes that the Survey should adopt for rocks in his study area a stratigraphic name that has been previously defined but has not been approved for use in Survey reports, he should (a) include a statement of intent, such as, "This unit, named by Smith in 1970, is here adopted," and (b) give a brief summary of Smith's description of the stratigraphic unit.

Changes in age designations

Changes in age designations of fossiliferous Phanerozoic rocks and their correlatives are subject to the approval of specialists in the Branch of Paleontology and Stratigraphy. Radiometric age determinations are judged by specialists in the Branch of Isotope Geology. The reasons for the age change should be stated in the report. As a note of caution, the author is reminded that the definition of a rock-stratigraphic unit is "independent of time concepts" (art. 4 (d) of the Code). Thus a rock-stratigraphic unit may be assigned to two or more systems or to two or more series.

Abandoned names

If the name of a rock-stratigraphic unit is to be abandoned, the author should state why and, if appropriate, give the name of the unit or units replacing the abandoned name. The name is referred to in subsequent reports as being obsolete, abandoned, or of former usage, or it is preceded by a dagger (†).

Changes in lithologic designation

Changes in lithologic designation are necessary when the rocks between the upper and lower contacts of a formally defined rock-stratigraphic unit vary areally in lithologic composition. Lithologic change over great distances may be due to depositional or postdepositional causes: For example, a sandstone may change to a quartzite, or a limestone to a dolomite, or a sandstone to a series of interbedded sandstone and shale. The lithologic description in the text is the place to delineate this change. The Survey prefers a lithologic designation to the word "formation" because it is more meaningful; when a rock-stratigraphic unit is more than 50 percent of a certain lithology, such as sandstone, it should be called sandstone and not formation. However, if a unit is composed of a mixture of lithologies, for example, sandstone and shale beds, the term "formation" can be used.

Stratigraphic redefinition

Redefinition of rock-stratigraphic units is the most complex and difficult change for an author to make. Many units have been redefined several times in various publications. The reader must then acquaint himself with each redefinition and, in his report, he must state whose redefinition he is following. Under extreme conditions it may be wisest to raise the stratigraphic rank or to abandon the unit.

Assignment to another stratigraphic unit

Regionally, a named member may extend from one formation into another, especially in areas where complex intertonguing takes place (art. 5 (e) and 7 (b) of the Code); the component formations of a group may also change (art. 9 (b) of the Code). The geographic limits and the reasons for the new assignment should be included in the discussion of the stratigraphic unit.

Change in stratigraphic rank

A formation may become a member of another formation, and a formation may become a group or vice versa (art. 16 of the Code). If a change in stratigraphic rank is required, the author should clearly give the areal limits of the rank change as well as the reasons for the change. Units of group rank must be divisible into two or more parts of formation rank, and each part must be given a formal name. A formation need not be divisible into formally named parts.

Geographic extension or restriction

Some rock-stratigraphic units can be recognized and mapped in several States; others are limited to very small areas. The name for a defined unit can be extended to separate rock bodies if they are believed to be homotaxial (art. 4 (b) of the Code). A report should include all available information concerning the geographic extent of named units.

Reinstatement of an abandoned name

On rare occasions, an abandoned name needs to be reinstated. This procedure is acceptable if the reinstatement will not cause confusion, if the original definition of the name is valid, and if the geographic name has not been applied to another stratigraphic unit. These points should be discussed with other geologists having knowledge of the area. A check of the name in the lexicon and review staff files is also necessary.

STRATIGRAPHIC DESCRIPTIONS

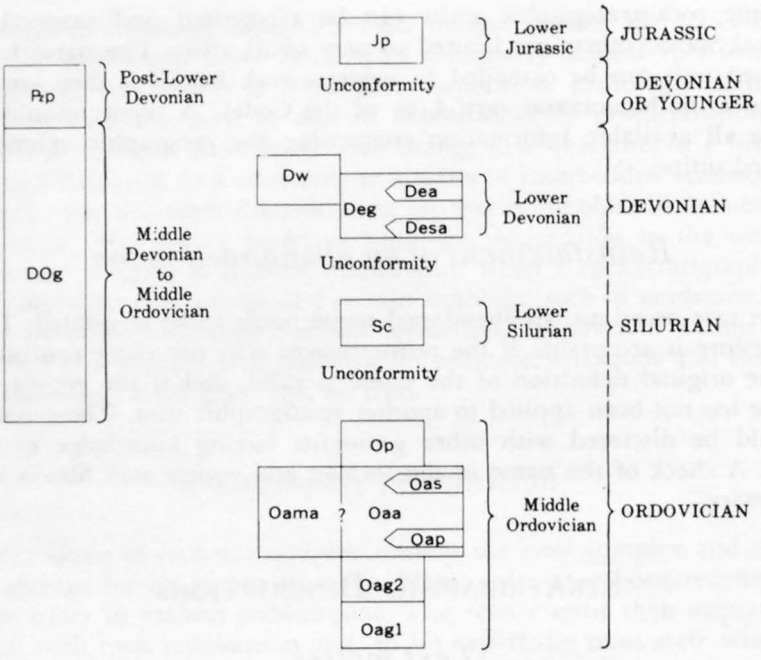
Text matter

In geologic reports the stratigraphy of an area is usually discussed chronologically, the oldest formation first and the youngest last. This usage does not necessarily apply to the order of discussion of strata penetrated in oil or water wells.

For all nomenclature changes, all the steps outlined in the Code for a particular change must be followed. If an abstract accompanies the report, the reader may benefit from inclusion of a summary of the stratigraphic changes being proposed. Those who read the abstract first may be enticed to read further if they know the full content of the report.

Usage of terms should be consistent, and the accepted term must be used throughout the report in referring to the study area. In paragraph headings, on maps, and for the first use of the name in a paragraph, the full formal name should be used. Confusion arises when geologic units with names like "Dakota" refer to a sandstone in most areas but to a quartzite in other areas, or when the Dakota in most areas is designated of formation rank but of a group rank in other areas. The Raritan Formation is an example of another type of geologic name that may cause confusion. It is divided into the Lloyd Sand Member (formal) and a clay member (informal). If frequent repetition of the term is necessary within a paragraph, a variation in style may be desirable, such as the Lloyd Member of the Raritan or the Lloyd.

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

Jp — PORTLAND FORMATION (JURASSIC)—Chiefly moderate-reddish-brown-weathering, thin-bedded, medium- to coarse-grained arkosic sandstone; minor siltstone and shale. Subordinate lenses of conglomerate 0.5–1.0 m thick in exposures southeast of Wilbraham near eastern border of unit. Most conglomerate clasts are pebbles or cobbles of pegmatite (Pzp below) or Glastonbury Gneiss (DOg below). Ratio of conglomerate to sandstone + siltstone + shale typically greater than 1:3 in exposures east of Wilbraham, less than 1:30 in exposures west of Stoney Hill Road School

Pzp — PEGMATITE (POST-LOWER DEVONIAN)—White to light-gray, weakly foliated to unfoliated sills, dikes, and irregularly shaped bodies consisting of quartz and feldspars with accessory muscovite, black tourmaline, sulfides, garnet, apatite, and rare beryl. Pegmatite bodies within Glastonbury Gneiss chiefly unfoliated. Locally they contain pink feldspar and smoky quartz crystals as large as 16–25 cm in longest dimension.

FIGURE 5.—Part of a typical map explanation. Abstracted from Pepper (1977).

Explanations for geologic maps

Rock-stratigraphic units on map explanations are arranged in vertical column (s) and in chronologic sequence, the youngest unit at the

ERVING FORMATION (LOWER DEVONIAN)

Deg — Generally gray-weathering biotite granofels interlayered locally with more abundant gray- and brownish-gray-weathering muscovite-biotite schist—Very minor amounts of very light gray quartz plagioclase-hornblende-garnet-sphene granofels and hornblende-plagioclase amphibolite. Biotite granofels is thinly to thickly parted and medium grained with mineral percentages as follows: quartz (30-50), plagioclase (20-45), biotite (20-30), garnet (1-3), and muscovite (1). Schist is medium- to coarse-grained, well-foliated, and consists of quartz (30-45), plagioclase (2-40), muscovite (15-35), biotite (5-20), garnet (1-3), and kyanite (3) with accessory potassium feldspar, chlorite, and apatite. Rectangular knots of very pale green muscovite and kyanite (0.6 mm in width), and knots and stringers of translucent quartz are characteristic of the schist

Dea — Thinly to thickly parted, medium- to coarse-grained hornblende-plagioclase amphibolite—Amphibolite contains minor amounts of epidote, sphene, and chlorite. Unit locally encloses minor thin layers of pink garnet-quartz rock (coticule) and plagioclase-quartz-biotite-hornblende-epidote gneiss

Desa — Generally hornblende-plagioclase amphibolite—Interlayered locally with more abundant rusty-weathering quartz-plagioclase-biotite gneiss and plagioclase-quartz gneisses containing variable amounts of hornblende, biotite, and garnet

Sc — CLOUGH QUARTZITE (LOWER SILURIAN)—White to light-tan, thinly layered quartzite and quartz-muscovite gneiss. A band of quartzite Sc is discontinuously exposed and is mapped at the base of amphibolite of the Erving Formation on the hill west and northwest of Worthington Pond, near the southern border of the Hampden quadrangle. Unit is exposed discontinuously for a distance of 100 m, in a band about 10 m wide, on the southwest slope of Mt. Marcy in the adjacent Ludlow 7½-minute quadrangle (Leo and others, 1977)

Op — PARTRIDGE FORMATION (UPPER MIDDLE ORDOVICIAN)—Rusty-weathering quartz-plagioclase-muscovite-biotite-(kyanite)-(garnet) schist interlayered with subordinate but appreciable quartz-feldspar-biotite-(hornblende)-(garnet) gneiss (30 percent) hornblende-plagioclase amphibolite (20 percent), and local quartz-garnet granofels. Schist weathers light brown and rusty moderate reddish brown, is medium to coarse grained, and well foliated, and contains accessory apatite, graphite, sulfide, and retrograde chlorite. Gneiss is medium grained, light to medium gray, and rusty weathering, and forms thinly to thickly parted, slabby layers

FIGURE 5.—Continued.

top and the oldest at the base (fig. 5). This arrangement is in contrast to the one recommended for the texts of geologic reports. Separate boxes in separate columns, but in the same horizontal position, are necessary where rock units of the same age have different names. Boxes in the explanation should be drawn as simply as possible, so the reader

can readily distinguish the map unit by symbol and color and can recognize its relationships to other units in the map area. Complex intertonguing of rock-stratigraphic units can be shown in a separate diagram below the explanation. If the relationship is unknown or uncertain, the map units may be enclosed by a brace and the uncertainty indicated at the right side of the brace. In the vertical column (s), boxes for individual map units are usually joined except where the individual map units are unconformable. The "uncomformity" is shown in capital letters between boxes for units so separated.

The current Survey format for a typical geologic-map explanation is shown in figure 5. Its design is dictated by modern preparation procedures, especially the use of the typewriter. Information in the explanation falls into two categories, correlation of map units and description of map units. Somewhat different formats for map explanation are shown in Scott (1972) and Scott and Taylor (1974).

CORRELATION OF MAP UNITS

The correlation of map units shows the general interrelationships of all the mapped units. The size for an individual box is determined by the number of other mapped units to which it is equivalent. Where several vertical columns are necessary, the author may wish to title the columns (fig. 5), depending on the reason for separating them. To the right of the map-unit boxes are the group, series (not epoch), system, and, occasionally, era braces (in that order). The series and system braces are essential.

The lettering associated with all the braces is placed horizontally. The system (and era, if used) is in capital letters. Group and series terms are in capital and lowercase letters. On some maps of surficial geology, separate braces to the left of the series braces are used for the named glaciations. The glaciation names are printed in capital and lowercase letters. The words "system" and "series" are not shown on map explanations (Jurassic, *not* Jurassic System; Upper Jurassic, *not* Upper Jurassic Series), but the words "group" and "glaciation" are shown (Glen Canyon Group; Pinedale Glaciation).

DESCRIPTION OF MAP UNITS

The description of map units is an abbreviated account of the lithology, color, and thickness of the rocks in each map unit. Each map unit is described in order of increasing age; the upper member of a formation is thus described before the middle or lower members. A box showing the map-unit symbol appears in the left column. The name of the rock-stratigraphic unit and its position (usually the series term) are placed in capital letters to the right; for example,

Jm MORRISON FORMATION (UPPER JURASSIC) * * *

STRATIGRAPHIC MAP SYMBOLS

Letter symbols applied to map units on geologic maps are unique to each map; they consist of capital and lowercase letters that represent two kinds of information. The capitalized first letter (s) stands for one or several of the time-stratigraphic units listed below.

Quaternary	Q	Ordovician	O
Tertiary	T	Cambrian	Ꞓ
Cretaceous	K	Cenozoic	Cz
Jurassic	J	Mesozoic	Mz
Triassic	Ŧ	Paleozoic	Pz
Permian	P	Precambrian	pЄ
Carboniferous	C	Precambrian Z	Z
Pennsylvanian	Ᵽ	Precambrian Y	Y
Mississippian	M	Precambrian X	X
Devonian	D	Precambrian W	W
Silurian	S		

If the rocks mapped belong to two systems, the symbol for the youngest system is listed first. For example, a Quaternary and Tertiary assignment would be shown as QT. If one map unit is assigned to more than two systems, the symbols for the youngest and oldest systems can be selected. For example, Quaternary, Tertiary, and Cretaceous will be QK.

The second letter or group of letters is in lowercase and stands for the rock-stratigraphic unit name. The letter or letters are chosen usually from the initial letters of the name, formal or informal, applied to that map unit. Series terms are not indicated in the symbol. Group names are seldom part of the symbol.

Repetition of the position term, such as Cretaceous or Upper Cretaceous, as part of the map-unit name should be avoided if that designation is also shown on the right-side brace (s). A suitable lithologic term (s) should be applied to the map unit that has no formal name, and the first letter of the first word of that term should be selected as part of the map symbol; for example, the map symbol for Cretaceous sedimentary rocks could be shown as Ks.

The total number of symbols applied to one map unit should not be less than two nor more than four. Map symbols should be used only on maps and not in the text of a report.

Use of subscript letters and numbers in map symbols is discouraged. Proper placement of the subscript takes time that can be saved by using normally placed letters. However, use of subscript numbers for Tertiary and Quaternary terrace deposits is conventional. It is also the convention to assign the youngest or lowest terrace deposit the number 1. The older or higher terrace deposits have the higher numbers, 2, 3, and so forth.

If a mapped area consists entirely or almost entirely of rocks belonging to one system, such as Quaternary (as in Richmond and Pierce, 1972) or Precambrian (as in Sheridan and others, 1972), the symbol for the system may be dropped as part of the map symbol; for example, fg may be used for a Quaternary fan gravel or mb for a Precambrian migmatitic biotite gneiss.

Correlation Charts and Stratigraphic Tables

The design of correlation charts and stratigraphic tables is complicated because their columns are read in both horizontal and vertical directions. Hierarchy or stratigraphic rank is shown for the geologic-time or time-stratigraphic and the rock-stratigraphic units by placing the largest or highest rank at the left side of each column. The units are given in order of increasing age, the youngest at the top and the oldest at the bottom.

As the terms are used here, correlation charts differ from stratigraphic tables in that the charts usually show the author's interpretation of rock-stratigraphic units in his report area and their ages as related to units that others have recognized elsewhere. A table usually lists, in proper age sequence (youngest at top and oldest at bottom), the rocks present in the report area. The sequence of vertical columns may give the age or position, name, thickness, lithology, and other pertinent information on each unit.

Time-stratigraphic or geologic-time terms are usually placed in the left-side columns of the chart or table. For readability, they may be repeated on the right side if the chart or table is large. Diagonal or vertical rules or shading usually connote missing rock; wavy or undulatory lines connote unconformities. All boxes for rock-stratigraphic units should be identified by name, whether the names are formal (Greenhorn Limestone) or informal (limestone or limestone member). The names are usually shown by capital and lowercase letters but the first letter of the first word in each entry, whether formal or informal, is capitalized. Abbreviations should generally be avoided, but if space is a problem the author may use one of the standard abbreviations and (or) he may expand the size of the box to accommodate the lettering (fig. 6: Wallace Creek Tongue), or he may give the box a footnote number and identify the rock unit by name in the footnote. Rarely, on some large tables, rock units are identified by a map symbol in the column (see, for example, Vecchioli and Miller, 1973, table 1). The symbol is usually explained in a headnote in which the rock-stratigraphic units are listed in proper stratigraphic sequence, the youngest explained first.

If a chart or table is a compilation of age and rock-unit assignments from several sources, the author may use individual headings at the top of each column. If the stratigraphy to be shown is extremely complex or poorly understood, the author may generalize by titling his chart

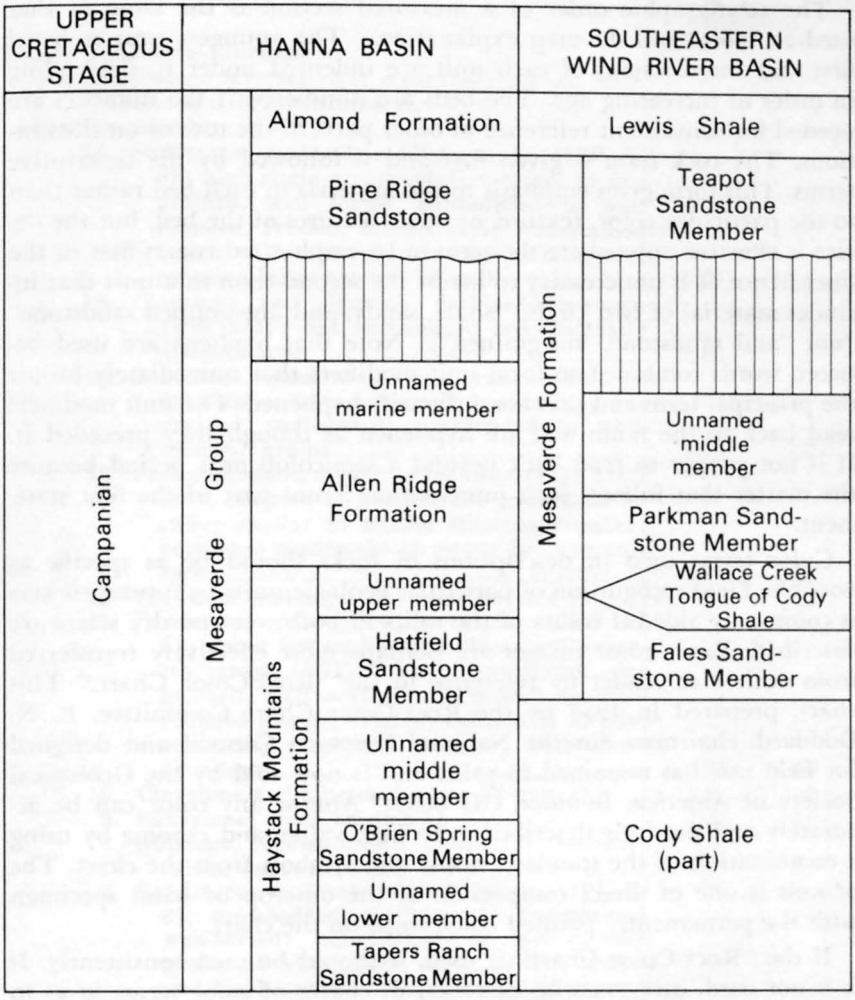


FIGURE 6.—Typical chart showing correlation of Upper Cretaceous rocks. Abstracted from Gill and others (1970, p. 6, 7).

or table as "A list of * * * (correlation of units shown in each column not implied)."

MEASURED SECTIONS

Measured sections accompany most stratigraphic reports. They may be included in the rock-stratigraphic unit discussion in the body of the text as when a new name is being established (see Rubey, 1973, p. 110) or an old name is redefined, or, if numerous sections are recorded, they may be placed at the end of the text (see Stewart, 1970, p. 71–200).

The stratigraphic order of a measured section is the same as that used in tables and on map explanations: The youngest unit is listed first and the divisions of each unit are indented under it, descending in order of increasing age. The beds are numbered if the numbers are needed for convenient reference in other parts of the text or on illustrations. The rock term is given first and is followed by the descriptive terms. This form gives emphasis to the material in each bed rather than to the particular color, texture, or other features of the bed, but the device is effective only where the term to be emphasized comes first in the line; hence, it is unnecessary to invert the second term in a unit that includes material of two kinds: "Shale, sandy, and fine-grained sandstone" (*not* "and sandstone, fine-grained"). Note that hyphens are used between words combined to form unit modifiers that immediately follow the principal term and that are ordinarily hyphened. The unit modifiers read back to the noun and are hyphened as though they preceded it. It is not proper to read back beyond a semicolon or a period because the matter that follows such punctuation is not part of the first statement.

Color terms used in descriptions of rocks should be as specific as possible. Field recognition of particular geologic units by future workers is commonly aided if colors of the units in both wet and dry states are described. Exact color images are perhaps most effectively transferred from author to reader by reference to the "Rock-Color Chart." This chart, prepared in 1948 by the Rock-Color Chart Committee, E. N. Goddard, chairman, for the National Research Council and designed for field use, has remained in print and is now sold by the Geological Society of America, Boulder, CO 80301. Almost any color can be accurately and precisely described as to hue, value, and chroma by using a combination of the standard words and symbols from the chart. The process is one of direct comparison of the outcrop or hand specimen with the permanently painted color chips on the chart.

If the "Rock-Color Chart" is used, it should be used consistently. If it is not used, care must be exercised in choice of color terms so as to convey clear and consistent meaning to the reader. Where the more exact designations are not required, "olive drab," "apple green," "royal blue," and similar terms may carry meanings that are sufficiently definite to make their use appropriate.

Combination color terms, like the three just mentioned, are separate words, but such terms are hyphened when they are unit modifiers:

reddish brown	reddish-brown siltstone
dark green	iron-gray shale
orange red	milky-white chert

The following sample measured section, the type section for a newly named rock-stratigraphic unit is abstracted and slightly modified from Green (1974, p. D3).

	Thickness (equivalents) Meters	Feet
Entrada Sandstone (Jurassic):		
Middle siltstone member. Not measured; contact with Iyanbito Member conformable.		
Iyanbito Member:		
16. Sandstone, moderate-reddish-orange (10*R* 6/6); high-angle crossbedded; medium to fine grained, well sorted, subrounded to well rounded, friable; mainly clear iron-stained quartz with minor dark accessory minerals; contains large amount of milky-white chert	5.79	19.0
15. Claystone and siltstone, dark-reddish-brown (10*R* 3/4); flat lens-shaped bed; laterally discontinuous	.03	.1
14. Sandstone, moderate-reddish-orange (10*R* 6/6), massive to crossbedded, fine- to very fine grained, well-sorted; subrounded to well-rounded grains	2.13	7.0
13. Sandy siltstone, moderate-reddish-orange (10*R* 5/6), massive to flat-bedded; calcareous locally; similar to middle siltstone member; polygonal mudcracks on upper bedding surface	5.18	17.0
12. Claystone and siltstone; same as unit 15	.1	.3
11. Sandstone, pale-yellowish-orange (10*YR* 8/6); upper few centimeters "bleached" greenish gray (5*GY* 8/1); crossbedded, fine grained, well sorted; subrounded to well-rounded grains; friable; calcareous locally; some silty zones and stringer; white chert abundant	.61	2.0
10. Claystone and siltstone; same as unit 15	.1	.3
9. Sandstone; same as unit 11	1.22	4.0
8. Siltstone, reddish-brown (10*R* 6/4), massive; calcite cemented along lower surface	1.83	6.0
7. Sandstone, moderate-reddish-orange (10*R* 5/6), crossbedded, medium- to fine-grained, well-sorted; subrounded to well-rounded grains of white, pink, clear, yellow, brown, and black quartz. Crossbeds dip an average of 20° SW	3.05	10.0
6. Sandstone; same as unit 11	3.05	10.0
5. Sandy siltstone; same as unit 13	2.44	8.0
4. Sandstone; same as unit 7	2.13	7.0
3. Claystone and siltstone; same as unit 15	.03	.1
2. Sandstone; same as unit 7	10.21	33.5
1. Sandstone, yellowish-gray (5*Y* 8/1), grayish-red (5*R* 4/2), and moderate-reddish-orange (10*R* 7/6), massive to crossbedded; coarse to fine grained, with pebbles and granules as much as 6 mm (about ¼ in.) across of white, black, clear, yellowish-green, gray, and pink quartz. Unit fills mudcracks as much as 1.2 m (4 ft) deep at the top of the underlying Owl Rock Member of the Chinle Formation	0.3	1.0
Total thickness of the Iyanbito Member	38.2	125.3
Chinle Formation (Triassic):		
Owl Rock Member: not measured; contact with overlying Iyanbito Member unconformable.		

Internal Consistency

When the author has completed his report, he should compare the abstract, stratigraphic charts, tables, map explanations, and text sections. Whether a rock-stratigraphic unit has a formal name, as Franklin Canyon Formation of Devonian (?) age, or an informal name, as a gabbro of Tertiary age, it must be recognizable in all parts of the report by that name and age.

Media for Publishing Stratigraphic Information

Before completing his report, the author of a paper containing stratigraphic information should consider, and discuss with his supervisor, the publication medium best suited for his work. Length, complexity of figures, of tables, or of stratigraphic changes, report area, and subject matter should be assessed in relation to the readers the author hopes to reach. For example, a paper of 20 double-spaced pages is too long for chapter A, "Contributions to Stratigraphy"; large maps and correlation charts even if compressed may not fit the size of a given medium; an International Geological Congress volume might not be the best publication for name changes for rocks in a small area of Colorado; a report on Quaternary terminology might reach the largest number of interested people in a journal devoted to study of that particular system. Certain types of reports, because of their format or lack of availability (open-file, for instance), are not proper vehicles for nomenclature changes (see art. 13 (c,e) of the Code).

U.S. Geological Survey publications

The Survey Bulletin or the Professional Paper series can be selected by the author when important stratigraphic information is included within an areal geologic report. The final selection of publication series is determined largely by the size of the illustrations, charts, and tables.

In 1963 the Survey started a special Bulletin series titled "Contributions to Stratigraphy" that is designed especially for the publication of stratigraphic papers. Chapter A always includes a listing of nomenclature changes adopted by the Survey for the year past as well as all short stratigraphic papers submitted by individual authors. The long papers are published as individual chapters and are given an alphabetical designation (B–Z, if 25 are submitted); they are published individually in order of receipt.

A brief description of all the stratigraphic nomenclature changes shown on Geologic Quadrangle and Miscellaneous Investigations Maps

should be added below the map explanation. If a new name is introduced, care should be taken to include all the pertinent information required for a new name because the map will have the first and, in some cases, the only published definition of the name.

For maps in other series, any new names, age changes, and other stratigraphic changes must be adequately described in a brief text on the map. At the time of approval by GNC, a copy of the text will be made and sent to the National Center at Reston, Va., for inclusion, under the author's name, in chapter A of "Contributions to Stratigraphy."

Publications restrictions

New stratigraphic names or significant stratigraphic changes should not be introduced in an abstract that is to be published separately from a more complete report. The essential conciseness of an abstract does not permit the full definition that is specified by the Code. In the abstract, an informal designation (for example, limestone of, at, or near Hudson) should be used for the stratigraphic unit that is to be named, and the unit should be described later in a more complete report.

Guidebooks are not generally used as a medium for naming new stratigraphic units because guidebook distribution and availability to the scientific public are limited.

A report containing new formal geologic names will be approved for open filing by the Director only when it accompanies or follows a standard publication in which the new names are introduced in the usual way. Age changes and other significant stratigraphic changes of established units will not be officially adopted on the basis of an open-file report.

A thesis prepared in connection with Survey work must be placed in open file. In preparing the thesis, the author should check proposed stratigraphic changes with a review staff member.

Stratigraphic Style and Expression

Abbreviations

Rock-stratigraphic, geologic-time, and time-stratigraphic terms should usually not be abbreviated. On charts, tables, graphs, and maps, if space is limited, the following abbreviations are acceptable. Periods are used in charts, tables, and graphs, but generally not on maps.

Term or lithology	*Abbreviation*	
	Formal	*Informal*
Group	Gp.	
Formation	Fm.	
Member	Mbr.	mbr.
Sandstone	Ss.	ss.
Siltstone	Sts.	sts.
Shale	Sh.	sh.
Limestone	Ls.	ls.
Dolomite	Dol.	dol.
Conglomerate	Cgl.	cgl.
Quartzite	Qtz.	qtz.
Volcanics	Volc.	volc.

System, period, or era	*Abbreviation*
Quaternary	Quat.
Tertiary	Tert.
Cretaceous	Cret.
Jurassic	Jur.
Triassic	Tri.
Permian	Perm.
Pennsylvanian	Penn.
Mississippian	Miss.
Devonian	Dev.
Silurian	Sil.
Ordovician	Ord.
Cambrian	Camb.
Cenozoic	Cen.
Mesozoic	Mes.
Paleozoic	Pal.
Precambrian	Prec.

Diverse time terms

DIVISIONS OF THE PRECAMBRIAN

Divisions of the Precambrian (table 1a) are based on isotopic or radiometric ages expressed in millions of years (m.y.). In Survey reports these divisions have currently replaced the more generally defined age divisions like Azoic, Archeozoic, Proterozoic, Algonkian, and Archean. However, the terms "Archean" for rocks 2,500 m.y. and older and "Proterozoic" for rocks 2,500 to 570 m.y. in age are being used by some geologists.

The divisions of the Precambrian are considered formal, although they have not been assigned formally to a specific part, such as systems, of the stratigraphic hierarchy. The scheme of these divisions has been devised simply to aid in the understanding of the Precambrian history of the United States. The time boundaries have been chosen so as to split as few of the known epochs of sedimentation, orogeny, and plutonism as possible. Intentionally, the boundaries do not correspond to

geologic events. The scheme is intended as an interim measure, pending development of an internationally accepted standard.

Some geologists believe that the informal terms "lower," "middle," and "upper" (or "early," "middle," and "late") Precambrian are meaningful, but these terms may have only local application in that the lower (or early) Precambrian in a given area, region, or State may not be equivalent to other rocks of the same position (or age) assignment in another area, region, or State.

PHANEROZOIC

The Phanerozoic Eon, which consists of the Paleozoic, Mesozoic, and Cenozoic Eras, has not been officially adopted by the Survey, but the term may be used in book reports when needed for convenience. No map symbol has been reserved for it. Alternatives to use of the term include use of all three terms listed above or the one term "post-Precambrian."

CARBONIFEROUS

The term "Carboniferous Systems" may be used when the Mississippian and Pennsylvanian Systems are not differentiated on maps, charts, and tables and in texts. However, use of the term is not required.

DIVISIONS OF THE TERTIARY

The terms "Paleogene" and "Neogene" have been used by some European geologists as divisions of the Tertiary System. In Survey reports, the Paleogene includes the Paleocene, Eocene, and Oligocene Series; the Neogene includes the Miocene and Pliocene Series. Some geologists have included the Pleistocene in the Neogene and some include both the Pleistocene and Holocene. The Paleogene and Neogene are neither part of the formal stratigraphic hierarchy defined in the Code nor part of the Survey's official nomenclature. The terms may be used in texts but not on map explanations, columnar sections, and correlation charts. No map symbols have been reserved for them.

PROVINCIAL LAND-MAMMAL AGES OF THE TERTIARY

Wood and others (1941, p. 8–13) devised a provincial time scale for the series of the Tertiary of the North American continent. The basis for each name is a rock-stratigraphic unit term or the name of a well-known local fauna with an added "an" or "ian" ending to distinguish the names as age terms. However, the most recent edition of the Code specifically states that it is improper to convert a rock-stratigraphic term to a time term by adding such endings (art. 34 (a)). These pro-

TABLE 1a.—*Major stratigraphic and time divisions*

[Compiled by Geologic Names Committee, U.S. Geological Survey]

Terms designating time are in parentheses. Informal time terms ("early," "middle," and "late") may be used for the eras, for periods, and for epochs where there is no formal subdivision into Early, Middle, and Late. Informal rock terms ("lower," "middle," and "upper") may be used where there is no formal subdivision of an era, system, or series.

Estimates for ages of time boundaries are under continuous study and are subject to refinement and controversy. Two scales are given for comparison. If neither Geological Society of London nor Berggren reference is used, author should cite the published source he follows. A useful time scale for North American mammalian ages is given by Evernden and others (1964, p. 145–198).

Subdivision in use by the U.S .Geological Survey			Age estimates commonly used for boundaries (in m.y.)	
Era or Erathem	System or Period	Series (Epoch)	Geological Society of London (1964, p. 260–262)	Berggren (1972, p. 195–215)
Cenozoic	Quaternary	Holocene (Holocene)		
		Pleistocene (Pleistocene)		1.8
	Tertiary	Pliocene (Pliocene)		5.0
		Miocene (Miocene)		22.5
		Oligocene (Oligocene)		37.5
		Eocene (Eocene)		53.5
		Paleocene (Paleocene)	65	65
Mesozoic	Cretaceous [1]	Upper (Late) Lower (Early)	136	
	Jurassic	Upper (Late) Middle (Middle) Lower (Early)	190–195	
	Triassic	Upper (Late) Middle (Middle) Lower (Early)	225	
Paleozoic	Permian [1]	Upper (Late) Lower (Early)	280	
	Pennsylvanian [1]	Upper (Late) Middle (Middle) Lower (Early)	[2] 320	
	Mississippian [1]	Upper (Late) Lower (Early)	345	
	Devonian	Upper (Late) Middle (Middle) Lower (Early)	395	
	Silurian [1]	Upper (Late) Middle (Middle) Lower (Early)	430–440	
	Ordovician [1]	Upper (Late) Middle (Middle) Lower (Early)	500	
	Cambrian [1]	Upper (Late) Middle (Middle) Lower (Early)	570	
Precambrian	Precambrian Z [3]		600	
	Precambrian Y [3]		1,600	
	Precambrian X [3]		2,500	
	Precambrian W [3]			

[1] Includes provincial series accepted for use in U.S. Geological Survey reports. See facing page.
[2] Geological Society of London (1964, p. 222).
[3] Informal time divisions.

TABLE 1b.—*Provincial series accepted for use in U.S. Geological Survey reports*

[Compiled by Geologic Names Committee, U.S. Geological Survey]

Series	Age	Region
Gulfian	Late Cretaceous	Texas, Louisiana, Oklahoma, Arkansas, Mississippi, and Alabama.
Comanchean	Early and Late Cretaceous	
Coahuilan	Early Cretaceous	Texas, Louisiana, Arkansas, Mississippi, and Alabama.
Ochoan	Late Permian	Texas and New Mexico.
Guadalupian	Early and Late Permian	
Leonardian	Early Permian	
Wolfcampian	Early Permian	
Virgilian	Late Pennsylvanian	Arkansas, Oklahoma, Kansas, Missouri, Nebraska, and Iowa.
Missourian	----do	
Des Moinesian	Middle Pennsylvanian	
Atokan	----do	
Morrowan	Early and Middle Pennsylvanian.	
Chesterian	Late Mississippian	Indiana, Kentucky, Tennessee, Illinois, Iowa, Missouri, and Arkansas.
Meramecian	----do	
Osagean	Early Mississippian	
Kinderhookian	----do	
Cayugan	Late Silurian	New York, Michigan, and Wisconsin.
Niagaran	Middle Silurian	
Alexandrian	Early Silurian	Missouri, Illinois, Michigan, and Wisconsin.
Cincinnatian	Late Ordovician	Ohio, Indiana, Kentucky, Tennessee, Michigan, Wisconsin, and Iowa.
Mohawkian	Middle Ordovician	New York, Michigan, Wisconsin, and Iowa.
Canadian	Early Ordovician	United States.
St. Croixan	Late Cambrian	Iowa, Minnesota, Wisconsin, and Michigan.

vincial ages also are not part of the Survey's formal nomenclature nor are they part of the formal stratigraphic hierarchy, but they are used in many reports; specific reference to the chart of Wood and others (1941) should be made when the terms are used.

NEOGLACIATION

"Neoglaciation" is a term used by some geologists to designate a readvance of the ice following the Hypsithermal (Thermal Maximum) interval. The term may be used only in reference to mountain areas where cirques and glaciers formed following the Hypsithermal (Mayer Rubin, oral commun., June 23, 1969).

Early, Middle, and Late vs. Lower, Middle, and Upper

The Survey makes a careful distinction between the use of time (geologic-time) and position (time-stratigraphic) terms. Many of the divisions of these two classification schemes are recognized internationally and have type or standard sections outside the United States. The initial letters of the formal or defined terms are capitalized; those of informal terms are not. Only formal terms are shown on table 1a, b. Mesozoic Era, Jurassic Period, Late Jurassic Epoch are formal time terms. The corresponding formal position terms are Mesozoic Erathem, Jurassic System, Upper Jurassic Series. Certain time and position terms,

such as early Mesozoic, late Paleocene, upper Quaternary, and lower Oligocene, are considered informal.

Provincial series terms are accepted as part of the formal nomenclature (table 1) for local areas and regions. The initial letters of each word are capitalized, as Gulfian Provincial Series.

The age of fossils is usually expressed by geologic-time terms. For example, fossils of Early Devonian age are Early Devonian fossils. But when it is necessary to distinguish between the organism and its residue, the time-stratigraphic term may be more appropriate: Fossils from Lower Devonian rocks are Lower Devonian fossils.

Formal nomenclature, examples

Stratigraphic classification schemes are listed below, and the appropriate articles of the 1970 edition of the "Code of Stratigraphic Nomenclature" are cited in parentheses.

A. Rock-stratigraphic units (art. 4–17)
   1. Absaroka Volcanic Supergroup
      Thorofare Creek Group
      Wiggins Formation
      Tepee Trail Formation
      Two Ocean Formation
      Langford Formation
      Promontory Member
   2. Pierre Shale
      Sharon Springs Member
      Ardmore Bentonite Bed
   3. Italian Mountain Intrusive Complex
   4. Niobrara Chalk
      Niobrara Shale
      Niobrara Formation
      Niobrara Limestone
      Niobrara Member of the Mancos Shale (Colorado)
      Niobrara Member of the Cody Shale (Montana)

B. Time-stratigraphic units (art. 26–35)
   Mesozoic Erathem
   Cretaceous System
   Upper Cretaceous Series
   Maestrichtian Stage

C. Geologic-time units (art. 36–38)
   Phanerozoic Eon
   Mesozoic Era
   Cretaceous Period
   Late Cretaceous Epoch
   Maestrichtian Age

D. Geologic-climate units (art. 39, 40)
Wisconsin Glaciation
Tazewell Stade
Two Creeks Interstade
Sangamon Interglaciation

Capitalization

Capitalization of the initial letters of formal geologic names was adopted by the Survey, along with the 1960 Code, in 1961. Geologic names in material quoted directly from sources written before that time should follow the usage of the original author. However, names in material that is paraphrased should be capitalized when adapted for use in manuscripts, tables, charts, and map explanations, even though they were not capitalized by the original author.

Examples of the proper capitalization of geologic terms are given below.

Jurassic System
Jurassic Period
Kimmeridgian Age
Oxfordian Stage
Upper Jurassic Series
Late Jurassic Epoch
the Upper Jurassic Morrison Formation
the Morrison Formation (Upper Jurassic)
the Morrison Formation of Late Jurassic age
Morrison age
early Bathonian age
Morrison time
the Morrison (?) Formation
the Morrison equivalent
equivalent to the Morrison
Dewey Lake Red Beds
Florissant Lake Beds
Vulcan Iron-formation
Traders Iron-Bearing Member
Elkhorn Mountains Volcanics
Ramey Ridge Complex

Diacritical marks

Use of diacritical marks in stratigraphic nomenclature and description is governed by the same principles that apply in use with personal and geographic names (p. 165, this text). The marks are not used on

anglicized words of foreign origin, on place names containing both foreign and English words, or on names of foreign origin applied to places in the United States. In reports on geology of foreign countries and on a territory or possession of the United States whose official language is not English, place names and other foreign words are generally written as they are used in the native language.

Undesirable expressions

Certain types of expressions should be avoided in geologic manuscripts:

1. Slang

   Permo-Penn., for Permian and Pennsylvanian
   Cambro-Ordovician, for Cambrian and Ordovician
   Je, as a shorthand version of Entrada Sandstone in a text

2. Unusual abbreviations

   Westwater Can. M or Westwater Member for Westwater Canyon Member

3. Misuse of rank term

   Series (a time-stratigraphic term) when Supergroup (a rock-stratigraphic term) is meant

Expressions for degrees of doubt

"Probably," "presumably," "may be," and "(?)" are used to express doubt about the correct rock-stratigraphic, geologic-time, or time-stratigraphic assignment. The aspect that is in doubt must be easily understood. For example, if a unit is "probably of Late Mississippian age," the practice of placing a query in parentheses is the most easily understood method. No one will be confused by Late (?) Mississippian.

When the identification of a geologic name is in doubt, the query is placed in parentheses after the geographic name, as Morrison (?) Formation.

Formal vs. informal names

Formal rock-stratigraphic units are those names that are defined in conformity with requirements of the Code (art. 3–17). For example, the Entrada Sandstone and its Dewey Bridge Member are formal units because they have type localities and their areal extent, lithology, contacts, and age have been described in a publication. The medial silty member of the Entrada Sandstone is not a formally defined member of that formation and is not capitalized. It has no type locality, and no published description is required for its use. The medial silty member of one author may or may not be the same unit as the one mapped as medial silty member by another author.

Formal names that have not been adopted by the Survey should be used with a citation, as Brachton Clay of Lewis (1881), the first time they appear in a text. References in abstracts should be avoided, but full reference should be given if used. The citation does not have to be repeated each time the term is used in the text, but repetition is advisable on tables, charts, and figures.

Quotation marks

Quotation marks are sometimes used around stratigraphic names by an author to indicate that the term has been abandoned or to imply misnomer or misapplication of the name. Because of the varied use and implications attached to the meaning of quotation marks, their usage in the stratigraphic context of a report should be explained, where practicable, by a brief statement.

Units of economic, local, subsurface, or regional interest

The names by which stratigraphic units of economic interest are known locally, such as oil sands, coal beds, and construction or ornamental stone, are considered informal names. Usually, only the first letter of the first word is capitalized. The text should state that the names are of local or economic interest or are used for subsurface units. Examples of such terms are:

Baker producing sand	Marker bed
Big Blue sand	Mineral coal bed
Blue Creek seam	Ore bed
Butte coal zone	Reef beds
Button beds	St. David cyclothem
Mahogany oil-shale bed	Vermont marble

Where the term has been replaced by a formal name, that name should be given preference. The economic term can be put in parentheses as follows:

Greenbrier Limestone (Big Lime)
Saltsburg Sandstone Member (Little Dunkard sand)

The terms "facies" and "sequence" are not part of the formal rock-stratigraphic classification scheme and are not capitalized, even though some geologists use them for names of rocks in local and regional areas. Terms such as Catskill facies and Sauk sequence are considered informal.

Names of intruded masses of igneous rocks, such as dike, sill, stock, pluton, batholith, and laccolith, are also not part of the formal rock-stratigraphic classification, though some such features have been as-

signed names such as the Idaho batholith and the Birch Creek pluton. In the descriptive material on map explanations and in texts, the lithology, rather than the structural form, should be emphasized, for example, "granodiorite of the Idaho batholith" or "quartz monzonite of the Birch Creek pluton."

Water-bearing rock units, or aquifers, may be named, but only where stratigraphic names cannot be used, for example, if the aquifer crosses stratigraphic boundaries or if an aquifer is known to exist but the local stratigraphy has not been worked out. To avoid confusion with stratigraphic units, aquifers to be named should be given broad regional names, such as the Floridan aquifer. The term "aquifer" is not capitalized.

For stratigraphic units that have been formally named and that are water bearing, the term "aquifer" may be used instead of the formal rock-stratigraphic term, for example, Jackson aquifer for Jackson Group or Catahoula aquifer for Catahoula Formation. If a single aquifer includes two or more named rock-stratigraphic units (Romero and Hampton, 1972), such as the Laramie and Fox Hills Formations, the name Laramie-Fox Hills aquifer may be used.

On maps showing hydrologic units, special symbols may be used for the aquifers, such as Fa for Floridan aquifer or Ja for Jackson aquifer.

Where formally named water-bearing rock-stratigraphic units are called aquifers, the description on the map explanation and in the text should make clear that these units are formal rock-stratigraphic units but that they are called aquifers on the map and in the text to emphasize their water-bearing character.

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GEOGRAPHIC NAMES

By Donald J. Orth

Geographic names are the proper names of particular places, features, and areas on the Earth's surface. They identify areas of cultural and administrative responsibility, define political boundaries, and carry legal weight in determining property, mineral, and water rights. For these reasons we are obligated professionally and legally to use official names in all publications and on all maps of the Geological Survey. The choice, form, spelling, and application of official place names for Federal usage are determined by the U.S. Board on Geographic Names.

U.S. Board on Geographic Names

First organized in 1890, the U.S. Board on Geographic Names was established in its present form by Public Law in 1947. Its mission is to serve the Federal Government as a central authority for solving problems, making decisions, and answering inquiries about geographic names. The Board performs a similar service for the general public. Any person or organization, public or private, may request the Board to decide formally on new names, name changes, or conflicting names.

The Board is composed of representatives from several Federal agencies and shares its responsibilities with the Secretary of the Interior. It is authorized to establish and maintain uniform geographic-name usage throughout the Federal Government. The Board has developed principles and policies governing the use of foreign and domestic names and the names of undersea and extraterrestrial features.

Domestic Geographic Names

The Domestic Names Committee of the Board is responsible for standardizing domestic geographic names of all places within the 50 States and within other areas under the sovereignty of the United States. The Executive Secretary and staff support for the domestic-names activities of the Board are provided by the Geological Survey.

The principle that guides domestic-names policy is formal recognition of present-day local usage. The Board works closely with State geo-

graphic committees or advisors, State and local governments, and the general public in order to determine choice, spelling, written form, and application of names for official Federal use. If there is confusing duplication or if local names are derogatory to persons, races, or religions, the Board may disapprove the names and seek alternatives. If local usage is conflicting or weak, well-established documented names and names with historical significance are given strong consideration. The Board does not approve new domestic geographic names that honor or may be construed to honor living persons.

The procedures for determining official standard names are carefully outlined by the Board. Several series of maps are recognized as authoritative and as basic references in editing geographic nomenclature for use in Federal publications and maps. These maps are:

1. Quadrangle maps of the National Topographic Map Series published by the U.S. Geological Survey
2. Nautical charts of coastal areas and inland waters published by the National Ocean Survey
3. Administrative and recreation maps published by the Forest Service, U.S. Department of Agriculture
4. Sectional aeronautical charts published by the National Ocean Survey

The choice, spelling, form, and application of names used on these maps are official unless they conflict with a decision of the Board or with local usage, or unless there is a conflict in usage among the maps. It is not the responsibility of a Survey author or editor to determine official standard names when conflicts are found. Problems should be submitted to the Board along with all pertinent information. The author or editor may recommend a choice based on the evidence. Lists of Board decisions are available in Survey libraries and in other Federal, State, university, and public libraries. Domestic-names decisions are now in computer storage and can be furnished in State, county, and area listings by writing to the Executive Secretary, Domestic Geographic Names, U.S. Board on Geographic Names, 523 National Center, Reston, VA 22092.

Proposing new names

When it is necessary to propose a name for an unnamed domestic feature, a report on the new name must be submitted to the Board for approval before publication of the paper that mentions the feature. Proposed new names should be unique and euphonious, if possible, and not unduly long or clumsily constructed. They should be acceptable to local citizens, and they should not be controversial. Indian or other ethnic names, if appropriate, and names suggested by local history or peculiarity of topographic feature, such as form, vegetation, or asso-

ciated animal life, are generally acceptable. Commonly duplicated words like elk, bald, mud, duck, round, or cottonwood should be avoided. The generic part of the name should conform to those common to the area, and the relational naming of forks, prongs, and branches of streams or canyons, such as East Fork or Middle Prong, should be avoided if possible, though sometimes such names need to be given to conform with existing relational names.

There is a restriction on the number and kind of new names approved for features in national parks and wilderness areas. New-name proposals for such features should be coordinated with park or wilderness supervisors before being submitted to the Board.

New names should be submitted to the Board with the following information:

Full name being proposed
Location and clear identification of feature
Reason for needing a name
Origin or meaning of proposed name

If the proposed name commemorates a person, additional information is needed:

Full name of the person
Birth and death dates (year)
Person's title and (or) profession or occupation
Person's association with the feature or area

A short biography of the person would be useful, and an annotated map showing the location and extent of the feature is also helpful. Because the Board works closely with interested Federal and State agencies, State geographic boards, and local citizens before deciding on a name, final action on a proposal may take 3 to 6 months.

Name-change proposals

The Board also considers name-change requests when there is strong reason to change the published name of a feature. Sometimes two nearby features have similar names, or a long-established published name may be inappropriate or in conflict with local usage. The reason for change should be clearly stated in submitting a case to the Board. Information concerning the possible effect of a name change on local citizens, the identification of the feature, and the origin or meaning of the new name should also be included.

Domestic names decisions

Name problems and proposals submitted to the Board are individually researched by the Geological Survey support staff and are put on

a monthly Docket List for consideration by the Domestic Names Committee. The lists are distributed to cooperating Federal and State agencies and to interested organizations and individuals about a month before the meeting at which the list is to be considered. Reviewing the merits of each case, the Committee decides between conflicting names and approves or disapproves proposed new names and name changes. Some cases are temporarily deferred to allow more time for State and local response or because more information is needed for a decision. A record of the decisions at each monthly meeting is submitted to the Secretary of the Interior for review. Decisions of the Domestic Names Committee automatically become decisions of the Board on Geographic Names and are published in a quarterly Decision List.

"Guidelines for Preparing and Submitting Proposals Regarding Domestic Geographic Names" has been published by the Board. Requests for copies and for Docket and Decision Lists and inquiries about domestic names, new-name proposals, and name-change proposals should be addressed to Executive Secretary for Domestic Geographic Names.

Foreign Geographic Names

Foreign names are handled by the Foreign Names Committee of the Board on Geographic Names, which is supported by an Executive Secretary and staff furnished by the Defense Mapping Agency, U.S. Department of Defense. The basic policy for determining standard names in foreign countries that use the Roman alphabet is to accept as official the written forms of names recognized locally. Names in countries that do not use the Roman alphabet are converted (transliterated) according to standard guides. The Board cooperates with agencies of foreign governments and with the United Nations to standardize foreign names for U.S. Government use.

The official standard forms of foreign names have been published by the Board in more than 100 gazetteers. Copies are available in the Geological Survey libraries in Reston, Va., Denver, Colo., and Menlo Park, Calif., and also in more than 600 Federal, State, university, and local libraries. Readers are encouraged to report all errors in the gazetteers. The source of the correction should be identified.

For names of foreign countries, for features such as large bodies of water outside national boundaries, and for a few populated areas and natural features in foreign countries, the Board has also approved optional use of names that are traditional (conventional) with English-speaking nations: "Jordan River (Mahr al Urdunn)," "Rome (Roma)," "Seoul (Sŏul)."

The Board has published both a "Romanization Guide" and a "Conventional Names Gazetteer." Requests for these books and inquiries concerning foreign gazetteers and foreign place names, including those

of underseas and extraterrestrial features and Antarctica, should be addressed to: Executive Secretary, Foreign Geographic Names, U.S. Board of Geographic Names, Defense Mapping Agency, Washington, DC 20305.

Nature of Geographic Names

Geographic names normally originate in and are influenced by spoken language. It is important to remember this fact because we are mostly concerned with written forms of names, including matters of spelling, capitalization, word form, and writing marks that have little or nothing to do with language.

Most geographic names are binomial in that they have two parts in the relation to each other of species and genus: Middleton (Middletown), Coal Hollow, or Sierra Nevada. The generic part tells the kind of place, feature, or area the name refers to, and the specific part modifies or uniquely identifies the particular place, feature, or area. The generic part of the name is usually a single topographic term like brook, hill, bay, peak, mesa, or lake; the specific part may consist of one or more words such as Grosse Roche, Jenny Lind Run, and Casale Campo di Carne. The binomial form is strong, and in written usage often leads to combining specific parts of the name, such as Threemile Run and Redhill Gulch. The names of some features can be long, especially if the specific part is a prepositional phrase: Cliffs of the Seven Double Pillars, Foot of the Mountains Run, and Cañon del Rajadero de los Negros.

Some names have nonce or unique generic forms; consider, for example, colorful American names like Bald Alley (ridge), Butlers Toothpick (pinnacle rock), Titans Piazza (hill), and Devils Racepath (ridge). Variations of the binomial form are one-word names that require a capitalized article: The Bend, La Pica, The Cape, The Nose, and The Maze. In sentence context, the names of certain kinds of features are preceded by the uncapitalized definite article; for instance, although the full specific-generic forms of such names are shown on maps (Potomac River, Mojave Desert, and Atlantic Ocean), the author may drop the generic part of the name in sentence context and refer to "the Potomac," "the Mojave," and "the Atlantic." When first used in text or when there is a possibility of misunderstanding, it is best to use the full name of the feature.

Single-word specific names like Boston, Oalite, and Pinhook are common for populated places and civil divisions; the kind of feature meant is implied by sentence context. Incorporated populated places and organized political areas often have an official name like "City of Denver," "Town of Northport," or "Commonwealth of Virginia," and a one-word common name, "Denver," "Northport," and "Virginia." Either form may be used in Federal publications.

Several names with the same generic word may be treated as a group in text with the generic word in plural form: "Calumet, Manitowoc, and Sheboygan Counties"; "Wisconsin and Illinois Rivers."

Capitalization of Geographic Names

With few exceptions, all words considered part of a proper geographic name are capitalized, including all adjectives, common nouns, and the definite article.

Adams Apple
Alva B. Adams Tunnel
Big Hill
Big Hole Basin
Cuchilla Buena Vista
Dark Hollow Brook
Farm River Gut
Lac Arnois
Little Captain Island
Los Caños
Old Fundamental Church
Pee Dee Ditch
The Crooked Esses
The Hogback
Upper Sulphur Creek
West Side Pond

Exceptions to the rule of capitalization include articles and prepositions in multiple-word names.

Alto de la Cruz
Cañada de Ojo del Agua
Fond du Lac
Gap in Knob
Lake of the Ozarks
Posta de Roque
Red River of the North
Rock of Ages
Scarce of Fat Ridge
Spread Eagle Chain of Lakes

As noted earlier, when the generic part of a name is purposely omitted, as in "the Potomac," "the Mojave," and "the Atlantic," the definite article preceding the specific name is not capitalized. Proper names of geographical entities such as regions, political divisions, populated places, localities, and physical features are capitalized in both the singular and plural.

Allegheny Front
Andromeda Cone
Atlantic Coastal Plain
Bighorn Basin
Blue Ridge
Brady Soil
Canal Zone
Central States
Catahoula Parish
Colorado Plateau
Colville Guide Meridian
Continental Divide
Dennison Township
Driftless Area
Eastern Shore
Fall Line
Fall Zone
Far East (Asia)
Front Range
Great Lakes
Gulf Coast
Gulf States
Half Dome
High Plains
Isle of Pines
Lower Town Landing
Middle Atlantic States
Monarch Geyser
Mount Rainier
Niagara Falls
North Atlantic States
North Slope
Pacific Coast States
Pine Ridge Reservation
Potomac and James Rivers
St. Stephens Base Line
San Joaquin Valley
Second Principal Meridian
Skyline Drive
The Chute
Tidal Basin
Upper Peninsula
Washington Metropolitan Area
West Coast (of the United States)
Western States

Qualifying words used in a general sense for parts of named areas are not capitalized. Care should be taken to prevent misunderstanding; for example, "western Virginia" or "the western part of Virginia" is preferable to "west Virginia." There are, however, borderline cases in which local residents and news media consistently use a qualifying word to modify the meaning of an existing geographic name in order to refer to a part of a State or other area. The modifying word then may become part of the proper name, to be uniformly capitalized with the rest of the name.

East Tennessee
Greater New York (City)
North Atlantic (Ocean)
South Mississippi
South Pacific (Ocean)
Upstate New York

Geographic-Geologic Names

Formal geologic-time and stratigraphic units are considered to have proper names, and the usual rules of capitalization apply (see "Stratigraphic Nomenclature and Description," p. 153).

Between strictly geographic and strictly geologic names, there is a gray area of informal names of features which may have both geographic and geologic significance. Most of these may be capitalized.

Book Cliffs Coal Field
Cincinnati Arch
East Texas Coal Field
Killarney Claim
Lillie Belle Prospect
Matchless Mine
Nacimiento Uplift
Santa Maria Basin
Vermejo Park Dome
Vienna Quadrangle
Williams Range Fault

Areas of indefinite extent are generally not capitalized.

ABC mining district
Lexington, Ky., area
Livengood gold placer deposit
Taconic region
Uravan mineral belt

Diacritical and Other Marks

Some diacritical marks may be essential to the spelling and form of an official name. These marks, such as the tilde (cañon), dieresis or umlaut (Korcë, Nürnberg), slash (Røros), macron (Kyūshū), cedilla (Iaşi), inverted cedilla (Dąbrowa), grave (Asmères), acute (Orléans), soft sign (Arkhangel'sk), circumflex (Nîmes), superior dot (Sharżysko Kamienna), and others, should be used as specified by the Board on Geographic Names. Diacritical marks are officially excluded in a few names such as Canon City in Colorado (not Cañon City).

Printing marks such as hyphens and apostrophes are occasionally used in domestic geographic names. Usage varies and care should be

taken to use the standard form for a particular feature. Hyphens are sometimes used in names consisting of a phrase (Hole-in-the-Wall, Go-to-it Creek, Be-Cha-Tu-Da Draw) and in names having a dual-form specific (Clark-Mallard Ditch, Alma-Cassville Trail).

Although a rare exception may be approved by the Board on Geographic Names, apostrophes suggesting possession or association are not to be used within the body of a proper name. The word or words that form a geographic name change their function and together become a single denotative unit. Thus, we write "Jamestown" instead of "James' town" or even "Richardsons Creek" instead of "Richard's son's creek." The whole name can be made possessive or associative with an apostrophe at the end as in "Rogers Point's rocky shore." However, apostrophes are often used within the body of a geographic name to denote a missing letter (Lake O'the Woods) or when they normally exist in a surname used as part of a geographic name (O'Malley Hollow).

Abbreviations and Number Names

Names of States can be abbreviated according to Government Printing Office standards. Other geographic names are not abbreviated in sentence context except that "Mount" and "Saint (e)" may be abbreviated as "Mt." and "St (e)." On maps and other illustrations, the generic part of a name and also a few modifiers ("Middle," "North," "South," "East," "West," "Left," "Right," "Saint (e),") may be abbreviated, but the specific part of a geographic name may not be abbreviated even in illustrations.

Numbers in names should be spelled out. Arabic numerals are number symbols, not words.

Fortynine and One Half Creek
Fourmile Run

PETROLOGIC TERMINOLOGY

Unlike such fields as mineralogy or paleontology, petrology has few generally accepted guides, official or otherwise, for nomenclature or description. As a result, even specialists in petrology may be confused by the welter of names and terms that have already been applied; they may be even more confused should they need to coin a new rock name.

Under these circumstances, two suggestions are appropriate:

1. Unless his paper is aimed primarily at other petrologists, the author should avoid unnecessary or overdetailed petrographic descriptions. He should, instead, include only the matter that has direct bearing on the overall purpose of the report. Thus a report on a mining district is hardly the place for introduction of a new rock name or for exhaustive descriptions of all the rocks and thin sections that have been examined. On the other hand, even minute features of the host rocks that may have a real bearing on the origin of the ore deposits or on the search for more ore warrant full description.
2. The petrologist should follow any of the several established classification schemes that best fits his needs. He should identify the system he has adopted if there is any chance of confusion with other classifications.

Instead of coining new names, it is generally considered desirable to apply modifiers, such as mineral prefixes, to existing rock names. For example, the term "biotite-hornblende granite" is self explanatory, and it avoids a long description and needless obfuscation of the literature that would be required to introduce a new name.

In using modifiers, Survey petrologists and many others follow a uniform scheme for use of hyphens that is based on the principle that like names are connected by a hyphen and unlike ones are not. The names used in such terms fall into four general classes: (a) rock names, (b) mineral names, (c) textural terms, such as porphyritic, gneissic, or vitrophyric, and (d) names expressing the kind of clastic aggregation, as agglomerate, breccia, or tuff. Names within any one class are hyphenated; others are not. The following examples illustrate the scheme:

biotite-pyroxene andesite
albite-epidote-chlorite schist
porphyritic nepheline syenite
trachyte tuff

To avoid confusion, an unhyphenated compound term should remain unhyphenated when it becomes a unit modifier preceding some other word, for example, "quartz monzonite dike."

Polysyllabic adjectives should generally be avoided in favor of shorter and simpler terms. Much depends on the intended audience, but even the specialist can understand terms like "fine-grained," "dark-colored," or "subhedral" as easily as he can words like "aphanitic," "melanocratic," or "hypidiomorphic."

The use of "acid," "basic," and "alkaline" in describing rocks and minerals was abandoned many years ago by the experts. Rocks are "silicic," not "acidic," if characterized by quartz. Rocks and feldspars are "alkalic," "calcic," "sodic," or "potassic," but not "alkaline." Similarly, "mafic" and "ferromagnesian" are preferred by most petrologists over the term "basic." (The word "basic" is a perfectly proper chemist's term for use in identifying the content of a mineral or other chemical compound.)

Normative Mineral and Molecule Tables

In petrologic tables giving normative minerals, the mineral names are generally abbreviated; lowercase letters are used for two-letter abbreviations and an uppercase letter is used for single-letter abbreviations. It is permissible to spell out the mineral names in petrologic tables, but first letters should be capitalized if the names are first words of a tabular column. In text, the author may abbreviate or spell out; usually the word "normative" is added before a spelled-out name and the name is begun with a lowercase letter. Abbreviation is used in text if percentage is given, as $en_{48}fs_{12}wo_{40}$.

The following list of abbreviations is according to the Cross, Iddings, Pirsson, Washington (CIPW) classification of igneous rocks (Washington, 1917, p. 46).

A____apatite subgroup (apatite, fluorite, calcite, pyrite, iron)
ab____albite
ac____acmite
an____anorthite
ap____apatite
C____corundum
cc____calcite
cm____chromite
cs____Ca_2SiO_4
di____diopside
en____enstatite
F____feldspar subgroup (orthoclase, albite, anorthite)
fa____fayalite
fo____forsterite
fr____fluorite
fs____ferrosilite ($FeSiO_3$)
H____hemic subgroup (magnetite, chromite, hematite)
hl____halite (NaCl)
hm____hematite
hy____hypersthene
il____ilmenite
ir____iron (metallic)
kp____kaliophilite
ks____potassium metasilicate
L____lenad subgroup (leucite, nepheline, halite, thenardite)
lc____leucite
M____mitic subgroup (magnetite, chromite, hematite, ilmenite, titanite, perofskite, rutile)
mt____magnetite
nc____sodium carbonate (Na_2CO_3)
ne____nephelite

ns____sodium metasilicate
O____olivine subgroup (fayalite, forsterite, Ca_2SiO_4)
ol____olivine
or____orthoclase (capped in OR_{35} situation)
P____pyroxene subgroup (acmite, sodium metasilicate, potassium metasilicate, diopside, wollastonite, hypersthene)
pf____perofskite
pr____pyrite
Q____quartz
ru____rutile
sp____spinel
T____tilic subgroup (ilmenite, titanite, perofskite, rutile)
th____thenardite, Na_2SO_4
tn____titanite
wo____wollastonite
Z____zircon

Reference

Washington, H. S., 1917, Critical discussion of the character and use of analyses, p. 9–46, *in* U.S. Geological Survey, Chemical analyses of igneous rocks • • •: U.S. Geological Survey Professional Paper 99.

CHEMICAL TERMINOLOGY

Chemical terminology is largely governed by the International Union of Pure and Applied Chemistry (IUPAC), although some individuals, laboratories, and publishers follow usages that differ from the Union's recommendations. New or revised decisions and rules as to atomic weights, chemical nomenclature, and other things are made by the Union from time to time. These are first published in various chemical journals, but updated summaries appear in yearly editions of the CRC Handbook of Chemistry and Physics (Weast, 1975).

Isotopes are commonly designated by the atomic number (the number of protons in the nucleus) and the mass number (the sum of the protons and neutrons in the nucleus). The custom of writing the mass number as a left superscript, as ^{14}C, is gradually becoming universal. Ratios, however, are generally more readable if the superscript follows the symbol, as Rb^{85}/Rb^{87}. Thus, an admixture of the two practices, even in the same paper, seems permissible. If the author chooses to use the form Rb^{85}/Rb^{87}, he should use it consistently for all his ratios. Where the full name of an element is used in text matter, the mass number is printed with a hyphen, as carbon-14. The atomic number is commonly omitted but if used it is written as a left subscript, $^{14}_{6}C$.

Chemical terms, rather than symbols, are generally used in the text. Symbols are used in tables and equations and may be used in text where it is desirable to avoid complex terms.

The following list of chemical elements, their symbols, atomic numbers, and atomic weights, which has been internationally adopted, is reprinted from "Journal of Pure and Applied Chemistry" (1976, p. 80–81).

The words "analyze" and "analysis" are often misused for "determine" or "determination." A report of "15 copper analyses" properly refers to 15 samples of copper ore which were analyzed for copper or for other elements; a report on the copper content of 15 rocks should refer to "15 copper determinations."

IUPAC rules call for use of Greek terms for adjectives and prefixes pertaining to valences and other stoichiometric properties. Thus, "monovalent," "divalent," "trivalent," "tetravalent," "pentavalent," and "hexavalent" are preferred, though the corresponding Latin prefixes "uni-," "bi-," "tri-," "quadri-," "quinque-," and "sexi-" are still used by some authors and publishers.

TABLE 2.—*Atomic weights, 1975*

Scaled to the relative atomic mass, $A_r(^{12}C) = 12$

The atomic weights of many elements are not invariant but depend on the origin and treatment of the material. The footnotes to this table elaborate the types of variation to be expected for individual elements. The values of $A_r(E)$ given here apply to elements as they exist naturally on earth and to certain artificial elements. When used with due regard to the footnotes they are considered reliable to ±1 in the last digit or ±3 when followed by an asterisk (*). Values in parentheses are used for certain radioactive elements whose atomic weights cannot be quoted precisely without knowledge of origin; the value given is the atomic mass number of the isotope of that element of longest known half life.

Alphabetical Order in English

Name	Symbol	Atomic number	Atomic weight	Footnotes
Actinium	Ac	89	227.0278	
Aluminum	Al	13	26.98154	z
Americium	Am	95	(243)	
Antimony	Sb	51	121.75*	
Argon	Ar	18	39.948*	w, x
Arsenic	As	33	74.9216	
Astatine	At	85	(210)	
Barium	Ba	56	137.33	x
Berkelium	Bk	97	(247)	
Beryllium	Be	4	9.01218	
Bismuth	Bi	83	208.9804	
Boron	B	5	10.81	w, y
Bromine	Br	35	79.904	
Cadmium	Cd	48	112.41	x
Caesium	Cs	55	132.9054	
Calcium	Ca	20	40.08	x
Californium	Cf	98	(251)	
Carbon	C	6	12.011	w
Cerium	Ce	58	140.12	x
Chlorine	Cl	17	35.453	
Chromium	Cr	24	51.996	
Cobalt	Co	27	58.9332	
Copper	Cu	29	63.546*	w
Curium	Cm	96	(247)	
Dysprosium	Dy	66	162.50*	
Einsteinium	Es	99	(254)	
Erbium	Er	68	167.26*	
Europium	Eu	63	151.96	x
Fermium	Fm	100	(257)	
Fluorine	F	9	18.998403	
Francium	Fr	87	(223)	
Gadolinium	Gd	64	157.25*	x
Gallium	Ga	31	69.72	
Germanium	Ge	32	72.59*	
Gold	Au	79	196.9665	
Hafnium	Hf	72	178.49*	
Helium	He	2	4.00260	x
Holmium	Ho	67	164.9304	
Hydrogen	H	1	1.0079	w
Indium	In	49	114.82	x
Iodine	I	53	126.9045	
Iridium	Ir	77	192.22*	
Iron	Fe	26	55.847*	
Krypton	Kr	36	83.80	x, y
Lanthanum	La	57	138.9055*	x
Lawrencium	Lr	103	(260)	
Lead	Pb	82	207.2	w, x
Lithium	Li	3	6.941*	w, x, y
Lutetium	Lu	71	174.97	
Magnesium	Mg	12	24.305	x
Manganese	Mn	25	54.9380	
Mendelevium	Md	101	(258)	
Mercury	Hg	80	200.59*	
Molybdenum	Mo	42	95.94	
Neodymium	Nd	60	144.24*	x
Neon	Ne	10	20.179*	v
Neptunium	Np	93	237.0482	z
Nickel	Ni	28	58.70	
Niobium	Nb	41	92.9064	
Nitrogen	N	7	14.0067	
Nobelium	No	102	(259)	
Osmium	Os	76	190.2	x
Oxygen	O	8	15.9994*	w
Palladium	Pd	46	106.4	x
Phosphorus	P	15	30.97376	
Platinum	Pt	78	195.09*	

TABLE 2.—*Atomic weights, 1975*—Continued

Name	Symbol	Atomic number	Atomic weight	Footnotes
Plutonium	Pu	94	(244)	
Polonium	Po	84	(209)	
Potassium	K	19	39.0983*	
Praseodymium	Pr	59	140.9077	
Promethium	Pm	61	(145)	
Protactinium	Pa	91	231.0359	z
Radium	Ra	88	226.0254	x, z
Radon	Rn	86	(222)	
Rhenium	Re	75	186.207	
Rhodium	Rh	45	102.9055	
Rubidium	Rb	37	85.4678*	x
Ruthenium	Ru	44	101.07*	x
Samarium	Sm	62	150.4	x
Scandium	Sc	21	44.9559	
Selenium	Se	34	78.96*	
Silicon	Si	14	28.0855*	
Silver	Ag	47	107.868	x
Sodium	Na	11	22.98977	
Strontium	Sr	38	87.62	x
Sulfur	S	16	32.06	w
Tantalum	Ta	73	180.9479*	
Technetium	Tc	43	(97)	
Tellurium	Te	52	127.60*	x
Terbium	Tb	65	158.9254	
Thallium	Tl	81	204.37*	
Thorium	Th	90	232.0381	x, z
Thulium	Tm	69	168.9342	
Tin	Sn	50	118.69*	
Titanium	Ti	22	47.90*	
Tungsten (Wolfram)	W	74	183.85*	
Uranium	U	92	238.029	x, y
Vanadium	V	23	50.9414*	
Xenon	Xe	54	131.30	x, y
Ytterbium	Yb	70	173.04*	
Yttrium	Y	39	88.9059	
Zinc	Zn	30	65.38	
Zirconium	Zr	40	91.22	x

[w] Elements for which known variations in isotopic composition in normal terrestrial material prevent a more precise atomic weight being given; $A_r(E)$ values should be applicable to any normal material.

[x] Element for which geological specimens are known in which the element has an anomalous isotopic composition, such that the difference in atomic weight of the element in such specimens from that given in the table may exceed considerably the implied uncertainty.

[y] Element for which substantial variations in A_r from the value given can occur in commercially available material because of inadvertent or undisclosed change of isotopic composition.

[z] Element for which the value A is that of the radioisotope of longest half-life.

The results of chemical analyses of rocks and minerals are generally reported in terms of weight percent of the oxides present. This practice naturally leads geologists to describe chemical changes in terms of the oxides, as "The introduction of silica and alumina during metasomatism * * *." This usage is often proper, but inconsistencies may arise because there is no convenient term for total iron oxides. Consider, for example, the sentence "Silica, magnesia, and iron were introduced," in which two oxides and one element are mentioned. Such difficulties can be avoided by describing chemical changes in terms of elements or perhaps by using the chemical symbols for the several oxides.

The rare-earth elements should never be referred to as rare earths. A rare earth is an oxide of a rare-earth element, hence the two terms are not interchangeable.

The spellings "sulfur," "sulfide," and "sulfate" have replaced the older spellings "sulphur," "sulphite," and "sulphate." "Beryllium (Be)"

and "niobium (Nb)" have replaced the names "glucinum (Gl)" and "columbium (Cb)," but "columbium" is still correct in some technical references such as to ferrocolumbium alloys (and the mineral columbite, which contains niobium as an essential element, is still called columbite). "Mercury" is the correct term for the chemical element, but "quicksilver" is correct in technical or industrial usage.

The term "lime" (CaO) is commonly misused for calcium (Ca). "Soda," meaning sodium carbonate (Na_2CO_3), and "potash," meaning potassium carbonate (K_2CO_3), are also commonly misused, both when the elements are meant, as in "potash feldspar," and when the oxide is meant, as in "The analysis shows 4.35 percent potash," meaning potassium oxide (K_2O). It is well, therefore, to be explicit and to write "potassium oxide" and "potassium carbonate" when referring to these compounds. In technical usage, the term "potash," as in "potash deposits of the United States," is deeply entrenched and should be retained.

References

Journal of Pure and Applied Chemistry, 1976, Table of atomic weights 1975: London, International Union of Pure and Applied Chemistry, v. 47, p. 80–81.

Weast, N. C., ed., 1975, Handbook of chemistry and physics (56th ed.): Cleveland, CRC Press, variously paged.

The 1975–76 (56th) edition contains current chemical signs, symbols, abbreviations, and a summary of rules for chemical nomenclature as established by the International Union of Pure and Applied Chemistry and Physics.

MINERALOGIC TERMINOLOGY AND DESCRIPTIONS

Proposals for new mineral names or for changes in existing mineralogical nomenclature should be made only after sufficient studies have convinced the author that such proposals are warranted. The namer should consult standard reference works, such as the Dana "System of Mineralogy" (Palache and others, 1944–62), Hey (1962), and Fleischer (1975), to avoid using a name that is identical to an existing name or whose pronunciation is close to one. The Survey, as well as many of the world's leading mineralogical and geological journals, requires that proposed new names be approved by the Commission on New Minerals and Mineral Names, International Mineralogical Association, in advance of publication. Requests for such approval may be made through channels or direct to the Commission, and the fact of approval should be recorded in the published paper. Commission decisions on requests are made in 45 days or less from the date of receipt; in order to avoid delays or disappointment in the author's choice of names, requests should be made before the manuscript is completed and ready for transmittal.

The following outline, from Donnay and Fleischer (1970, p. 1017–1018), lists the kinds of data that are ideally desired for description of a new mineral species. It will also serve as a check list for preparing a detailed description of any mineral occurrence or assemblage.

Introduction. Statement of name, mineralogical classification (oxide, sulfate, etc.) and relationships, generalized characterization.

Occurrence. Locality (in identifiable form), type of host rock, paragenesis (including associated minerals, replacements observed, alterations, texture), abundance of mineral (tons or micrograms?), size of crystals.

Chemistry. Chemical analysis (state purity of samples); if electron probe analyses were used, give the standards used, the number of determinations, and the range of values, as well as the averages; actual and idealized formulae; determinative chemical reactions, especially solubility and fusibility; synthesis and stability relations, if known; DTA and TGA, especially for minerals containing volatiles; spectrographic analysis.

Crystal geometry. Cell dimensions and volume, all with standard deviation (state numerical value of X-ray wavelength used); Laue class, diffraction aspect or space group (state extinctions observed); number of formula units (for actual formula) per cell * * *; observed and calculated densities; indexed X-ray powder data with intensities; relations to other known structures.

Crystal morphology. Goniometric axial ratio(s) and angles; crystal forms and form combinations; habit; malformation, cleavage(s) (Miller indices, quality, facility); twinning (twin law and composition surface); gliding; parting.

Physical properties. Color, luster, streak, grain size; hardness (micro-hardness); density; pyro- and piezo-electric properties; magnetic susceptibility; infrared absorption spectrum; fluorescence.

Optical properties. If transparent, indices of refraction, optical sign, $2V$, dispersion (s), optical orientation, elongation, pleochroism; calculated index of refraction. If opaque, color in air and oil; reflectivity and its dispersion (state standards used), anisotropism, bireflectance, polishing hardness and quality.

Type specimen. State where and how much type material is deposited, giving identification number (s) if possible.

Name. Derivation, pronunciation, preferably with International Phonetic Symbols. If a mineral is named for a living person, his or her consent must be obtained. If it is proposed to change an existing name, or to redefine an already named mineral, the person who gave the previous name must, if living, be given an opportunity to comment on the proposal.

Coinage of new varietal names for minerals should be avoided if possible by the use of the adjectival modifiers proposed by Schaller (1930, p. 566–574). For example, "ferroan sphalerite" is preferred to "marmatite" and "manganoan cummingtonite" to "dannemorite." The scheme for forming these adjectival modifiers from the names of chemical elements is briefly paraphrased from Schaller (p. 570–571) as follows:

The names of the chemical elements are placed in seven groups. In each of the first six groups all the names have the same ending; the seventh group includes names having various endings. The adjectival endings are formed according to the rules given for each group. Latin names are used for copper (cuprum), gold (aurum), iron (ferrum), lead (plumbum), silver (argentum), and tin (stannum). If lower valency is to be expressed, use "oan" instead of "ian," as in "ferroan" and "ferrian."

Group 1. If the name ends in "um," drop the "um" and add "ian."
Aluminum—aluminian
Tantalum—tantalian

Group 2. If the name ends in "ium," drop the "um" and add "an."
Barium—barian
Cerium—cerian

Group 3. If the name ends in "ine," drop the "ne" and add "an."
Bromine—bromian

Group 4. If the name ends in "on," add "ian," except for boron and silicon.
Carbon—carbonian
but
Boron—borian
Silicon—silician

Group 5. If the name ends in "gen," add "ian."
Hydrogen—hydrogenian
Nitrogen—nitrogenian
Oxygen—oxygenian

Group 6. If the name ends in "y," drop the "y" and add "ian."
Antimony—antimonian

Group 7. For the following names use the form shown.
Arsenic—arsenian
Bismuth—bismuthian
Cobalt—cobaltian
Manganese—manganian
Nickel—nickelian
Phosphorus—phosphorian

Sulfur—sulfurian
Tungsten—tungstenian

Where an element shows more than two valencies, the proper form can easily be made. Thus, for vanadium:

For vanadous vanadium, valency of 3, use vanadoan.
For vanadyl vanadium, valency of 4, use vanadylian.
For vanadic vanadium, valency of 5, use vanadian.

Some practical examples of this scheme follow:

Barian celestite
Calcian siderite
Rubidian lepidolite
Uranoan zircon (uranous uranium)
Uranian fergusonite (uranic uranium)
Zincian tetrahedrite

In addition, the following forms can be used:

Hydroxyl—hydroxylian
Sulfate—sulfatian
Carbonate—carbonatian
Phosphate—phosphatian

The symbol used generally for the index of refraction, and specifically for the index for isotropic substances, is n. A variety of symbols has been used in the past for the indices of refraction for uniaxial and biaxial crystals, but only two are in common current usage. These are:

	Uniaxial	*Biaxial*
1.	ω, ϵ	α, β, γ
2.	nO, nE	nX, nY, nZ

The names preferred for the 32 crystal classes are those of Groth as modified by Rogers (see Palache and others, 1944, p. 8). The symbols for face, form, and zone (or axis) are indicated by the type of brackets enclosing the indices. Thus, in the ditetragonal-dipyramidal class, (001) refers to the face at the plus end of the c axis, {001} to the two faces (001) and $(00\bar{1})$ that make up the form; [001] refers to the axis of the zone; any face within this zone is parallel to the line [001]. The space-group symbols are to be given first in terms of the International symbol (see Bragg and others, 1935) and second in terms of the Schoenflies symbol (see Schoenflies, 1923). Thus, for murdochite, which is cubic, the statement would be $Fm\bar{3}m$ (O_h^5).

Two units of measurement have been used in the past in reporting X-ray data, the "angstrom unit" (A) and the "kX unit." All data should be given in angstrom units, one angstrom unit equaling one nanometer, or 10^{-8} cm ($A = 10^{-8}$ cm). Angstrom units are related to kX units by the equation 1.00202 kX = A. To avoid ambiguity, however, the type of radiation and the wavelength value or values used should be specified in all X-ray work.

References

Bragg, W. H., Laue, M. T. F. von, Hermann, Carl, editorial committee, 1935, Internationale tabellen zur bestimmung von kristallstrukturen [International tables for the determination of crystal structures]: Berlin, Gebruder Borntraeger, v. 1, 2, 602 p. (paged continuously).

Donnay, Gabrielle, and Fleischer, Michael, 1970, Suggested outline for new mineral descriptions: American Mineralogist, v. 55, p. 1017–1018.

Fleischer, Michael, 1975, 1975 Glossary of mineral species: P.O. Box 783, Bowie, Md. 20715, Mineralogical Record, 145 p.

"* * * an alphabetical list as of 1–1–75 of the names, symmetry, and chemical composition of mineral species * * *" (title page).

Hey, M. H., 1962, An index of mineral species and varieties * * *; 2d, revised edition, reprinted with corrections: London, printed by order of the trustees of the British Museum, 728 p. Title on spine: Chemical index of minerals.

"* * * arranged chemically, with an alphabetical index of accepted mineral names and synonyms * * *" (title page).

Palache, Charles, Berman, Harry, and Frondel, Clifford, 1944 (v. 1), 1951 (v. 2), 1962 (v. 3), The system of mineralogy of James Dwight Dana and Edward Salisbury Dana: New York, John Wiley, v. 1, 834 p.; v. 2, 1,124 p.; v. 3, 334 p.

This seventh edition of the bible of mineralogists was entirely rewritten and greatly enlarged by Palache, Berman, and Frondel. Dana's work was first published in 1837 and thus is one of the oldest scientific reports of America.

Schaller, W. T., 1930, Adjectival endings of chemical elements used as modifiers to mineral names: American Mineralogist, v. 15, p. 566–574.

Schoenflies, Artur, 1923, Theorie der kristallstruktur; ein lehrbuch [Theory of crystal structure; a textbook]: Berlin, 555 p.

PALEONTOLOGIC MATTER

By J. Thomas Dutro, Jr.

Fossils, the stuff of geologic history, deserve the same meticulous descriptive care as that used in describing a favorite rock or mineral. Because there are certain rules in the zoologic and botanic sciences with regard to priorities and other legalities, descriptions of fossils must be made with scrupulous attention to detail. In taxonomic papers, these descriptions should be as complete as warranted by the specimens available. Clarity and brevity are the goals of descriptive paleontology, as in all good scientific writing. However, clarity should never be sacrificed for the sake of brevity.

All descriptions of species should contain a brief diagnosis, a full morphologic description, indication of the types and other specimens used for the description and their repositories, accurate information about the locality from which the fossils came (including stratigraphic and geographic detail), comparison with other similar species, and remarks on variability of features. Discussion of phylogeny, ontogeny, functional morphology, paleoecology, and biostratigraphic importance are included where significant.

If the species has been described before, a synonymy showing the history of usage of names applied to the taxon is included.

Species are illustrated, as completely as feasible, with photographs, line drawings, and charts showing variation in morphologic structures.

Descriptive terms vary from phylum to phylum, and some words are used with different meanings in different fossil groups. Proper terminology can be learned from examination of recent pertinent monographs, the "Treatise on Invertebrate Paleontology" (Moore, various dates), and other similar sources.

A sample format for species description:

Generic assignment, describer's name, date
Species name
Plates and figures of illustrations
Synonymy
Diagnosis
Description
Material, including types, with museum numbers and indication of repository
Measurements, with charts and graphs showing variability, where practicable
Discussion and comparison

Generic descriptions are similar to specific ones, with special emphasis on an accurate diagnosis and an unambiguous designation of the type species.

Suprageneric assignments are indicated where they are not obvious or redundant.

SYNONYMY

In paleontologic writing, the history of usage of a name is given in a synonymy. There are several styles that may be used, depending on what the writer wishes to emphasize. Generic synonymies usually first list former usages of the genus in the sense of the writer and then list synonyms, incorrect usages, questionable assignments, and errors. All are in chronologic order. A similar style may be used for species synonymies, although a strictly chronologic listing, with correct and incorrect references in their proper order, is becoming more generally accepted.

In the past it was customary to give complete bibliographic references for each item in a synonymy, generally because they were not given at the end of the paper. It is now more common for synonymies to be condensed and for full references to be given in the bibliography.

The basic requirement for a synonymy is that it clearly express the history of usage of the name given to a taxon and present the writer's conclusions about the validity of the name. Because this aspect of paleontologic writing often gives much trouble to writer and editor alike, examples of several generic synonymy styles are given:

1. The complete form including reasons for some of the assignments, although it is not essential to give the reasons:

Genus PARAPARCHITES Ulrich and Bassler, 1906, emend. Scott, 1959

Paraparchites Ulrich and Bassler, 1906, Proceedings of the National Museum, v. 30, p. 149. Scott, 1959, Journal of Paleontology, v. 33, no. 4, p. 673.

Antiparaparchites Coryell and Rogatz, 1932, American Midland Naturalist, v. 13, no. 6, p. 387. Based on reversal of overlap.

Ardmorea Bradfield, 1935, Bulletins of American Paleontology, v. 22, no. 73, p. 138. Based on steinkern.

Microcoelonella Coryell and Sohn, 1938, Journal of Paleontology, v. 12, no. 6, p. 597. Based on juvenile.

?*Cyathus* Roth and Skinner, 1930, Cooper, 1941, Illinois State Geological Survey Report of Investigations 77, p. 61.

2. Condensed format; full reference to each paper given in the bibliography:

Genus DERBYIA Waagen, 1884

Derbyia Waagen, 1884, p. 576, 591; Hall and Clarke, 1892, p. 261; Schellwien, 1900, p. 10; Girty, 1909, p. 181; Dunbar and Condra, 1932, p. 75; Sokolskaya, 1960, p. 209.

Derbyina Grabau, 1931a, p. 259, 262 (Graubauellina Licharew, 1934).

Grabauellina Licharew, 1934a, p. 507.
Derbyaeconcha Licharew, 1934a, p. 507.
Plicatoderbya H. D. Thomas, 1937, p. 13–18.

3. A strictly chronologic format:

Genus SYRINGAXON Lindström, 1882

1882. *Syringaxon* Lindström, p. 20.
1900. *Laccophyllum* Simpson, p. 201.
1902. *Nichelsonia* Počta, p. 184. Cited in plate explanations *Alleynia* (*Nichelsonia*).
1928. *Laccophyllum* Simpson. Grabau, p. 82.
1928. *Alleynia* Počta (*Nichelsonian* Počta). Grabau, p. 82.
1935. *Syringaxon* Lindström. Butler, p. 117.
1938. *Syringaxon* Lindström (in part). Prantl, p. 21.
1940. *Syringaxon* Lindström. Lang, Smith, and Thomas, p. 129.
1949. *Syringaxon* Lindström. Stumm, p. 10.
1956. *Syringaxon* Lindström. Hill, p. F258.
1962. *Syringaxon* Lindström (in part), Flugel and Free, p. 224.

Similarly, there are several styles that can be used for species synonymies. Two of these, the first according to usage of names and the second according to chronology of references, follow.

Pentagonia unisulcata (Conrad)

Atrypa unisulcata Conrad, 1841, p. 56.
Atrypa uniangulata Hall, 1861, p. 101.
Meristella? *unisulcata* (Conrad). Hall, 1862, p. 158, pl. 2, figs. 17, 20–23 (not figs. 19, 24, 25).
Meristella (*Pentagonia*) *unisulcata* (Conrad), Hall, 1867, p. 309, pl. 50, figs. 18–29 (not figs. 30–35).
Not *Meristella unisulcata* (Conrad). Nettleroth, 1889, p. 99, pl. 15, figs. 9–16.
Pentagonia unisulcata (Conrad). Stauffer, 1915, p. 104, 245 (not p. 160, 171, 175, 234); Dunbar, 1919, p. 87, 89; Goldring, 1935, p. 148, figs. 53B–D; Butts, 1940, p. 300, 301, 304, 305; Butts, 1941, pl. 115, figs. 17–21, 35; Cooper and others, 1942, chart; Cooper, 1944, p. 333, pl. 127, fig. 27; Oliver, 1954, p. 633, 634, 638–640; Oliver, 1956, p. 1452, 1456, 1462, 1469; Rickard, 1964, chart; Boucot and others, *in* Moore, 1965, p. M656, pl. 533, figs. 2a–d (not figs. 2e–f); Oliver and others, 1969, chart.
Not *Pentagonia unisulcata* (Conrad). Savage, 1930, p. 47, 50, 53, 62; Savage, 1931, p. 242, pl. 30, figs. 17, 18.

Goniatites crenistria Phillips

1836. *Goniatites crenistria* Phillips, Illustrations of the geology of Yorkshire, pt. 2, p. 234, pl. 19, figs. 7–9.
1836. *Goniatites vesica* Phillips, Illustrations of the geology of Yorkshire, pt. 2, p. 236, pl. 20, figs. 19–21.
1897. *Glyphioceras incisum* Hyatt (part). Smith, Proceedings of the California Academy of Science, 3rd ser., Geology, v. 1, no. 3, p. 111–121, pl. 13, figs. 1, 2, 6–12, pl. 14, figs. 1–9, pl. 15, figs. 1–11 (not pl. 13, figs. 3–5).
1903. *Goniatites crenistria* Phillips (part). Smith, U.S. Geological Survey Monograph 42, p. 68–76, pl. 14, figs. 1, 2, 7–12, pl. 15, figs. 1–9, pl. 16, figs. 1a–j, pl. 26, figs. 1–4 (not pl. 10, figs. 12–16, pl. 14, figs. 4–6, pl. 26, fig. 5).
1910. *Goniatites crenistria* Phillips. Grabau and Shimer, North American Index Fossils, v. 2, p. 141, figs. 1393f–h.

1911. *Goniatites choctawensis* Shumard (part). Girty, U.S. Geological Survey Bulletin 439, p. 97–99, pl. 15, figs. 7, 7a (not figs. 1–6).
1911. *Goniatites crenistria* Phillips. Girty, U.S. Geological Survey Bulletin, 439, p. 99–101, pl. 15, figs. 8, 9.
1924. *Goniatites crenistria* Phillips. Bisat, Proceedings of the Yorkshire Geological Society, v. 20, pt. 1, p. 78–82, pl. 3, figs. 4, 5, pl. 9, fig. 1.
1925. *Glyphioceras crenistria* (Phillips) (part). Schmidt, Preussischen Geologischen Landesanstalt Jahrbuch, v. 45, p. 565, 566, pl. 21, figs. 1, 3, pl. 23, fig. 14 (not pl. 2, fig. 2, pl. 23, fig. 13).
1952. *Goniatites crenistria* Phillips. Bisat, Transactions of the Leeds Geological Association, v. 6, pt. 4, p. 173, 174, text fig. 3 (b).

A Few Guidelines

All formal fossil names are in Latin and are italicized. Names used informally and adjectives based on fossil names are not italicized: Pectens, spirifers, bryozoans, productids, Ostreas, foraminifers, and others. All generic and suprageneric names are capitalized.

Genus and species names agree in gender according to rules of classical grammar. Gender does not necessarily indicate the sex of the object in question. Many Latin nouns ending in *-us* are masculine, in *-a* are feminine, and in *-um* are neuter, but there are exceptions. Classical grammars should be consulted when in doubt as to gender. Brown's "Composition of Scientific Words" (1954) is indispensible for anyone trying to compose scientific names for use in systematics.

The name of the first describer of a taxon should be included in all references to that taxon, although the name can be omitted in tables and elsewhere, at the discretion of the paleontologist, if earlier reference to the describer is clear.

When a species is reassigned to a genus other than the original one, the name of the first describer is placed in parentheses and the reviser's name is added. The proper citation for the olenellid trilobite that was first described as *Olenus thompsoni* by Hall in 1859, but later was used as the type species for *Olenellus* by Billings, is *Olenellus thompsoni* (Hall) Billings.

The rules of the taxonomic game are different for animals and plants. Anyone writing about fossils should study the two standard nomenclatural guides carefully (Lanjouw and others, 1956; Stoll and others, 1961).

Various degrees of certainty in identification of taxa are expressed by modifications in citation of fossil names. For example:

Taxon	*Degree of certainty*
Spirifer cf. *S. grimesi* Hall	Taxon compared with named species
Spirifer aff. *S. grimesi* Hall	Taxon has affinities with named species
Spirifer? *grimesi* Hall	Species questionably assigned to genus
Spirifer grimesi Hall?	Species doubtful, but assigned to correct genus
?*Spirifer grimesi* Hall	Entire assignment doubtful

A species name is composed of two parts; the first is the generic name and the second is the trivial name. Despite a clear statement by Schenk and McMasters (1956, p. 13), among others, confusion concerning this basic fact continues.

The name of the original describer of a taxon should not be abbreviated.

The English forms of "n. gen.," "n. sp.," "not," "s.s.," "part," "of authors," "undet.," "indet.," and so on, are to be used rather than the Latin forms.

An unpublished name, or "nude" name, is invalid and should not be included in any manuscript unless it is certain that the description of that species will be published before the manuscript is published.

Generic names may be abbreviated where they are a part of a species name, as long as the full name has been used earlier in the paper and there is no confusion with other generic names having the same initial letter.

Those who cite systematic identifications and opinions of others should quote accurately, with original qualifying statements and with clear reference to source and date of communication.

In species descriptions, it is essential that the nature of the material on which the description is based be stated. This requirement includes (a) number and condition of specimens, (b) sex and growth stage where known, (c) measurements of all important morphologic features and indication of variability, and (d) an unambiguous indication of the types and their repository.

Descriptions of taxa may be in complete sentence form or they may be in telegraphic style. As with synonymies, however, a consistent format is used throughout any particular paper.

Formats for different journals vary; the suggestions for authors of papers submitted to any specific journal should be followed closely when designing a contribution to that journal. This procedure ultimately avoids grief for writer, critic, and editor alike.

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Lanjouw, Joseph, and others, 1956, International code of botanical nomenclature: Utrecht, Kemink en Zoom, 338 p.

Moore, R. C., ed., [various dates], Treatise on invertebrate paleontology: University of Kansas Press and Geological Society of America; various parts.

Schenk, E. T., and McMasters, J. H., 1956, Procedures in taxonomy: Stanford, Calif., Stanford University Press, 119 p.

Stoll, N. R., and others, 1961, International code of zoological nomenclature: London, International Trust for Zoological Nomenclature, 176 p.

NUMBERING SYSTEMS FOR SAMPLES AND SPECIMENS

Diverse identifying numbering systems are used by different institutions to indicate where type or other specimens of fossils or minerals are deposited. Thus, the inclusion of a serial number in the description of a new fossil species tells the reader that the type specimen on which the species is erected is preserved in the paleontologic collections of the U.S. National Museum, the American Museum of Natural History, the Harvard Museum of Comparative Anatomy, or other permanent repository. Similar numbering systems are applied by groups within the Survey and by many other groups to identify the final homes of collections of fossils from specific localities, of analyzed samples of rocks, ores, minerals, and the like. Such permanent numbers are indispensable to future researchers and should be used in published reports wherever applicable. Informal and temporary numbering systems, such as those applied by the field geologist to materials collected on a particular project, and numbers applied to a series of samples during laboratory analysis seldom have a place in a final report. In general, material that is of permanent value and that will need to be physically retrieved by some future worker should be identified with a permanent collection number that will be meaningful to specialists.

Records of the permanent repositories of significant specimens such as type fossils or minerals are made far more valuable if the exact spots from which the specimens were collected are also recorded permanently. Some scientists are understandably reluctant to pinpoint the locations of their discoveries for fear that the remaining fossils, crystals, or other treasures will be removed or vandalized by others. Each individual must balance in his own mind the potential damage to his collecting locality against possible benefits to science by its disclosure. On some large-scale geologic maps the collecting locality can be shown by symbol. Whether or not a map accompanies the report, the locality should be described by reference to permanent topographic features, to the land-survey (section, township, and range) system, to latitude and longitude, or to the Universal Transverse Mercator projection grid.

GEOLOGIC REPORTS AND THE COMPUTER

By Ralph N. Eicher

Today most reports originating within the Survey will have come into contact with a computer or a computer product at some stage in their processing. The basic data in the report may have been retrieved from a computerized data base, or they may have been reduced to camera-ready copy through use of a computer that has a special program for photocomposition. Text-editing or word-processing systems provide yet another auxiliary capability for producing a report by computer.

Technical advancements are occurring rapidly in practically every scientific field, and they are particularly noticeable in the computer field. In fact, at times it appears that formal documentation of these changes lags behind the implementation of such innovations within the Geological Survey; this lag is the mark of any changing technology. With due consideration of this state-of-the-art, it should be noted that the Computer Center Division personnel are highly knowledgeable about the latest technical advances in the computer industry. This expertise is extended to all prospective Geological Survey computer users at any time, and users are urged to consult with field branch or headquarters personnel during project planning or during the early stages of project development.

The computer equipment and technology of the Geological Survey are available, on a cost-repay basis, to all Survey scientists. They are also available under special arrangements, at the same rates, to other government scientists and to non-Federal and quasi-Federal governmental agencies, such as State cooperators and The American Red Cross, and to earth-science professional organizations. The non-Survey users must either furnish their own programs that are compatible with Survey computer equipment or use a program that the Survey has developed. Survey scientists who need to use non-Survey equipment or technology must obtain current regulations for such use through their Division channels or the nearest Survey computer center.

Equipment and Technology

The Geological Survey currently (1977) maintains major computer centers at National Headquarters in Reston, Va., Regional Head-

quarters in Denver, Colo., and in Menlo Park, Calif., the Flagstaff, Ariz., Field Center, the Mid-Continent Mapping Center in Rolla, Mo., the Special Mapping Center of the Topographic Division in Reston, and the Earth Resources Observation Satellite (EROS) Data Center in Sioux Falls, S. Dak. There are teleprocessing terminals at most of the Water Resources Division district offices and at such centers as the Conservation Division office in Metairie, La., the Water Resources Division's Southeastern Regional Headquarters in Atlanta, Ga., the Center for Marine Geology in Corpus Christi, Tex., and the Gulf Coast Hydroscience Center at Bay St. Louis, Miss. All these terminals can communicate with the computers maintained and operated by the Computer Center Division at National Headquarters in Reston. In addition, the Computer Center Division has time-sharing systems in Reston, in Denver, and in Menlo Park which provide services to Geologic Division personnel and to other Geological Survey personnel upon special arrangements.

The Survey plans by 1989 to have a network of some 500 terminals communicating principally with the major computers at Reston, Denver, and Menlo Park, but having the capacity, through these major centers, of communicating also with each other. Actually, even by today's technology a user's access to a major computer system is limited only by his access to a telephone. Many Survey employees when in the field have made their motel rooms into temporary computer centers. Portable terminals are readily available, and all that is required to use one is a telephone, a small device called an acoustic coupler, and some knowledge of how to access the desired computer.

Training and Technical Support

Each of the seven Survey computer centers offers courses in programing as well as courses in procedures for accessing its particular computer. Further information about the procedure for requesting the use of one of these computers or about the characteristics of a particular computer can be obtained from the chief of the appropriate facility. Periodically each facility publishes and disseminates to its users a bulletin containing topical, but usually transient, information related to its computer.

The Computer Center Division at National Headquarters publishes the "U.S.G.S. Computer Users Manual" which contains information of more permanent nature. This manual is intended to serve as a technical guide for programers who use Computer Center Division services and facilities. Much of the information is machine-dependent, but the manual does contain information which is not otherwise available in any other form or medium. It also provides information from widely scattered sources which are inconvenient to use as individual references. For instance, the manual describes the kinds of services furnished by the Computer Center Division and itemizes the kinds of equipment

available at each center. It also discusses such items as utility routines and other special-purpose programs, describes relevant operating-system languages, tells how to set up a job so it can be executed, how to use efficiently such storage facilities as magnetic disks and tapes, and how to add and use programs stored in the program library. One chapter of the manual deals with the documentation of a computer program (see p. 189–190). The National Headquarters Computer Center maintains a source-program library, access to which permits the user to discard the trays of cards after his program has been made operational. Technical standards, such as flow-chart symbols, are described in another chapter of the manual. Copies of the manual can be obtained by other computer centers from the Geological Survey, Computer Center Division, Branch of Computer Information, MS 804, Reston, VA 22092.

Data-Base Systems

A data base can be defined as all of the information collected, stored, and available for use through a given computer system. Data-base management uses a computer program or a collection of computer programs to systematically store, update, and retrieve information previously stored as data items, most of which are in the form of records in a file. Common access to a data base may be made simultaneously by many users, even from remote installations.

The success of a data-base management system is measured by its ability to structure and make available a data base. A data base can be compared to a filing cabinet: properly organized, it yields specific information quickly and easily. Lack of structure makes retrieving data as difficult as finding the right report in four drawers labeled "Miscellaneous."

The fundamental elements of data-base management systems are a dictionary or thesaurus and data descriptions. A data dictionary is a list of code names used in the system and the description or identification of the intended meaning of the names in that system. Data descriptions define the characteristics of a data item in terms of name, length, content, and level.

A data base organized with information management in mind allows selective retrieval of information at any level of detail. The EROS Data Center, for example, can retrieve a Landsat photograph of a given geographic location taken within a specified time frame and when the cloud cover is 10 percent or less. In most data-base management systems, the data, once retrieved, can be displayed as a listing on a line printer or can be used as input to other computer programs which may perform production scheduling, statistical analyses, or cost accounting or which may prepare the data to produce plots or contour maps.

Data-base structure also determines the ease with which data in the system may be updated. The easier a record is to locate, the easier it can be corrected and put back into its proper place.

Some data-base management systems are interactive. With a telephone and an acoustic coupler the user, equipped with a typewriter or a cathode ray tube (CRT) terminal, can communicate directly with the computer. Interactive systems operate at least part of the time in a conversational mode. The user takes some action such as typing a word, and the computer responds. Then the system requests input, and the user responds. Different systems have different degrees of interactivity. Generally, the more interactive a system is, the easier it is to use and the more responsive it becomes to the user's needs.

The alternating stimulus-response interplay is sometimes referred to as the "feedback loop" in the "man-machine interface." By eliminating the completing of coding forms, the key-punching, the batch-job submitting, the waiting for return of results, and all associated inadvertent errors, the feedback loop is shortened and the level of complexity in using the system is lowered. As soon as the user enters something, he gets something back; if it's right he keeps it, if it's wrong he can change or delete it. There is no detailed programing involved, just give-and-take based upon an immediately understandable response.

Dissemination of Data-Base Information

Emphasis within the Geological Survey on the creation and maintenance of data bases has made possible the distribution of information to the public in at least three ways:

1. Data can be selectively retrieved from the data base, listed in conventional tabular formats with accompanying textural information, and published in one of the current series of publications. However, if the data to be published are voluminous, the author should consider alternative ways of distributing the data so as to make them available to the public in a timely manner.
2. If the data to be published are static (for example, all geophysical measurements for a given quadrangle), then they can be copied onto a magnetic tape and sent to the National Technical Information Service (NTIS) for distribution. A short description of contents of the tape and the physical format in which the data are recorded must accompany the tape. NTIS has established qualifying parameters for magnetic tapes that are sent to them for distribution. These parameters are available from the Survey's Computer Center Division or from the author's nearest Survey publications-distribution unit.
3. If the data base is dynamic, the author should consider allowing other governmental agencies and a selected segment of the public

direct access to the data through their own terminals. Direct access to the data base is possible only when the terminal equipment is compatible with the type of computer hardware at the site where the data base is maintained. An example of dynamic data base is WATSTORE (National WATer Data STOrage and REtrieval System), maintained by the Survey's Water Resources Division. WATSTORE contains information that is supplied to it through the Division's many activities associated with water-resource data.

Authorization to access a given data base must be obtained from the chief (or his authorized representative) of the Survey Division maintaining the data base. When the request is approved, the new user receives a notice of authorization along with an assigned agency (users) code and account numbers for proper identification. Information from the file is then available for the user.

The originating Division must prepare a users' guide for its data base. This guide should contain a general administrative-information section that will include user-related information, access procedures, data security, program options, cost and billing procedures, and generalized file descriptions. Another section should provide more detailed information which the user will have to know in order to access the data base. Additional sections of the guide will describe individual data files within the data base as well as the procedures to be used for retrieving and displaying data.

Automated Bibliographic Searches

There are particular kinds of on-line data bases on which bibliographic searches can be made. Normally such services are contracted. The Geological Survey has access to GeoRef, the geological-reference data base (or file) produced by the American Geological Institute. The file provides worldwide coverage of the geoscience literature in 21 fields. It covers approximately 3,000 journals and includes special coverage of conferences, symposia, and major monographs. Each citation in the 21 fields can be searched in 13 categories, though only eight of the 13 can be indexed for rapid and direct search. All information in a citation can be requested through various print commands. To perform this service, Survey library personnel request some useful keywords or phrases related to the subject of the search and a brief narrative description of the subject area. They need to know the years of interest and also whether non-English citations are acceptable.

In addition to GeoRef, the Department of the Interior provides bibliographic search services to "Chemical Abstracts" and 16 other bibliographic data bases; information about the use and costs of these services is available from the Geological Survey Library.

Characteristics of Interactive Computer Terminals

Interactive terminals fall into two major categories: those that print data (teleprinters) and those that display data (alphanumeric display terminals). Teleprinters have traditionally been used as interactive terminals because they were the only type available. However, since its inception in the middle 1960's, the alphanumeric display terminal has been accepted as the ideal man-machine interface for a broad range of applications.

A teleprinter terminal may be defined as any device that combines a serial printer with a data-communications interface. A keyboard is an important component of most teleprinters, though its presence is not required. Serial printers are so named because they print one character at a time. Depending upon whether or not the paper is mechanically struck, such printers are classified as either "impact" or "nonimpact." In both techniques there are two subcategories: "full-character" and "matrix" printers. Generally, full-characters are more desirable because of their high legibility. In contrast, characters produced by a matrix printer consist of a series of dots. In terms of speed and costs, the full-character impact printer is usually the least expensive in cost but the slowest in operation. Nonimpact printing techniques, such as the ink-jet, offer increased speed of operation but at a much higher cost per terminal.

The alphanumeric display terminal is a purely electronic device whose operating speed is virtually instantaneous. Most of these terminals use CRT as a display device; other types of displays include light-emitting diodes (LED), plasma (gaseous) displays, and liquid-crystal displays (LCD). The salient features which these terminals offer are reliability (no electromechanical parts), editing and formatting (flexibility), fast operation (300 to 1,200 characters per second), and convenient output medium (no supplies, paper, or ink required). Hard-copy attachments are available for some of these terminals, but the quality of the printed matter is inferior to that produced by teleprinters.

Selection of terminal should be based upon the types of applications for which the terminal will be used. Teleprinters should be selected when minimum cost and (or) the need for high-quality printing are the selection criteria.

Documentation of Computer Programs and Automated Data Systems

A computer program is a plan or routine consisting of a series of instructions for solving a problem on a computer. Automated data systems are composed of a group or collection of logically related computer programs having to do with a particular activity.

The planning, design, development, and implementation of computer programs and automatic data systems (software) represent a considerable investment of human and computer resources. To maximize the return on this investment, adequate documentation should be required at each step of the software-development life cycle. Documentation provides information which supports the effective management of automatic data-processing resources and, within the context of STA 6, it also facilitates the interchange of information. It serves to inform potential users of the functions and capabilities of the software. Thus, the users are able to determine the applicability of the available software to their needs.

Basically, the intent of software documentation is no different from that of other types of reports. It is the sharing of knowledge acquired through studies and investigations. As with the fundamental requirements for any report, documentation should be well prepared and credible. It should receive careful and adequate review. It should be given editorial scrutiny if it is to be published (many documentations are prepared for internal use only). Finally, it should conform to policies and practices of the Geological Survey.

Usually, but not necessarily, the subject matters of documentations are temporary in nature. Thus the documentations normally represent a nonpermanent form of publication and should not be considered a part of formal publication. Ordinarily they are released through the Geological Survey's series of open-file reports or through NTIS.

The Computer Center Division has long recognized the need for adequate documentation. To support this need, special guidelines were drawn up and published as chapter 8 of the user's manual. These guidelines were subsequently augmented by Federal Information Processing Standards Publications 38, "Guidelines for Documentation of Computer Programs and Automated Data Systems," issued by the National Bureau of Standards on February 15, 1976.

The material included in documentations depends largely on the judgment of the originator. In deciding upon the material to include, the author should take into consideration the need, the audience, and bulk of the document. Later work and the costs involved must also be considered. Multipurpose computer programs are expected to be more thoroughly documented than those of a single-use, experimental type.

Computer-Related Dictionaries

Authors or readers concerned with a computerized process may wish to use as guides in the understanding and proper usage of computer terminology the two dictionaries annotated below.

James, Glenn, and James, Robert C, 1949, Mathematics dictionary: Princeton, Van Nostrand, 432 p.

An exhaustive collection of definitions of terms and principles beginning with those of arithmetic and extending through those of abstract mathematics; includes an extensive coverage of statistical terms. Through this "correlated condensation of mathematical concepts, * * * the general reader can come to an understanding of concepts in which he has not been schooled by looking up the unfamiliar terms in the definition at hand and following this procedure down to familiar concepts" (from "Preface," unpaged). The dictionary has particular relevance because of the advent of geomathematics.

Sippl, Charles J., and Sippl, Charles P., 1972, Computer dictionary handbook (2d ed.) : Indianapolis, Howard W. Sams, 778 p.

Contains over 22,000 definitions and concept explanations related to electronic data processing, information technology, computer science, and automation. Contains hundreds of the new abbreviations and acronyms. Includes terms and definitions in such computer-allied knowledge areas as operations research, management science, model building, data communications, industrial automation, and flow-charts. The text explains a new language which "takes strange forms because it is part mathematics, part logic, part English, part electronics, and part machine nomenclature; and it is constantly changing and growing" (from "Preface to First Edition," unpaged).

THE METRIC SYSTEM

By Solomon M. Lang and Anna May Orellana

In 1948 the Ninth General Conference of Weights and Measures by its Resolution 6 instructed the International Committee of Weights and Measures "to study the establishment of a complete set of rules for units of measurements" and "to make recommendations * * * suitable for adoption by all signatories to the Meter Convention." The International System of Units (SI), which has been adopted by almost all nations, was the outgrowth of this resolution.

SI differs from the old centimeter-gram-second system in that (a) the base units are more accurately defined and (b) specific directives and guidelines are provided for use of prefixes and for the development of combined units. SI is described in National Bureau of Standards Special Publication 330 (1974). Guidelines for use of SI are provided in the "Standard for Metric Practice" (1976), which is Publication E 380–76 of the American Society for Testing and Materials and Publication 268–1976 of the Institute of Electrical and Electronics Engineers; this publication has also been adopted by the American National Standards Institute.

The major scientific advantage of SI is that it comprises a consistent and coherent set of units whose use will ease exchange of data in many disciplines where English (U.S. customary) units of measure have been used.

In March 1973, in anticipation of official national adoption of SI, the Director of the Geological Survey issued a memorandum which stated that use of dual SI and customary systems would be obligatory in Survey publications, commencing July 1, 1973. In "reports intended primarily for scientific audiences, metric (SI) units should be given first, followed by subordinate English units in parentheses. In reports intended primarily for the general public, metric units should be subordinate in position," the directive stated. In recognition that in certain publications use of the dual units might present difficulties, authority was granted Division Chiefs to waive the requirement in individual instances.

In 1975, when the Metric Conversion Act was passed by Congress and signed by the President, the United States officially expressed its intent to join other nations in use of SI. The act recognizes the need for a conversion period until such time as SI can be used exclusively.

The U.S. Geological Survey Metrics Panel, headed by a Metrics Coordinator, was organized in 1976 to develop specific guidelines and time schedules and to monitor progress in adoption of SI units for all Survey scientific and mapping activities. On the Panel's recommendation in October 1976, the Chairman of the Geological Survey's Executive Committee directed the use of only SI metric units in the Journal of Research of the U.S. Geological Survey. During the conversion period, other Survey publications may use either customary or SI units, depending upon the audiences to which they are directed. Toward the end of the conversion period all Survey publications will contain only SI units.

The most frequently used SI and customary units and factors for their interconversion are given in the following table.

TABLE 3.—*Conversion factors for SI metric and U.S. customary units of measurement*

[SI (International System of Units) a modernized metric system of measurement. An asterisk after the last digit of the factor indicates that the conversion factor is exact and that all subsequent digits are zero; all other conversion factors have been rounded to four significant digits. Use of hectare (ha) as an alternative name for square hectometer (hm^2) is restricted to the measurement of small land or water areas. Use of liter (L) as a special name for cubic decimeter (dm^3) is restricted to the measurement of liquids and gases. No prefix other than milli should be used with liter. Metric ton (t) as a name for megagram (Mg) should be restricted to commercial usage, and no prefixes should be used with it]

A. Factors for converting SI metric units to U.S. customary units

To convert from	To	Multiply by
	Length	
millimeter (mm)	inch (in)	0.03937
meter (m)	foot (ft)	3.281
	yard (yd)	1.094
kilometer (km)	mile (mi)	0.6214
	mile, nautical (nmi)	0.5400
	Area	
$meter^2$ (m^2)	$foot^2$ (ft^2)	10.76
	$yard^2$ (yd^2)	1.196
	acre	0.0002471
$hectometer^2$ (hm^2)	acre	2.471
$kilometer^2$ (km^2)	$mile^2$ (mi^2)	0.3861
	Volume	
$centimeter^3$ (cm^3)	$inch^3$ (in^3)	0.06102
$decimeter^3$ (dm^3)	$inch^3$ (in^3)	61.02
	pint (pt)	2.113
	quart (qt)	1.057
	gallon (gal)	0.2642
	$foot^3$ (ft^3)	0.03531
$meter^3$ (m^3)	$foot^3$ (ft^3)	35.31
	$yard^3$ (yd^3)	1.308
	gallon (gal)	264.2
	barrel (bbl), (petroleum, 1 bbl=42 gal)	6,290
	acre-foot (acre-ft)	0.0008107
$hectometer^3$ (hm^3)	acre-foot (acre-ft)	810.7

TABLE 3.—*Conversion factors for SI metric and U.S. customary units of measurement*—Continued

A. Factors for converting SI metric units to U.S. customary units—Continued

To convert from	To	Multiply by
Volume per unit time (includes flow)		
decimeter^3 per second (dm^3/s)	foot^3 per second (ft^3/s)	0.03531
	gallon per minute (gal/min)	15.85
	barrel per day (bbl/d), (petroleum)	543.4
meter^3 per second (m^3/s)	foot^3 per second (ft^3/s)	35.31
	gallon per minute (gal/min)	15,850
Mass		
gram (g)	ounce avoirdupois (oz avdp)	0.03527
kilogram (kg)	pound avoirdupois (lb avdp)	2.205
megagram (Mg)	ton, short (2,000 lb)	1.102
	ton, long (2,240 lb)	0.9842
Pressure		
kilopascal (kPa)	pound-force per inch^2 (lbf/in^2)	0.1450
	atmosphere, standard (atm)	0.009869
	bar	0.01*
	inch of mercury at 60°F (in Hg)	0.2961
Temperature		
kelvin (K)	degree Fahrenheit (°F)	([1])
degree Celsius (°C)	degree Fahrenheit (°F)	([2])

[1] Temp °F=1.8 temp K−459.67. [2] Temp °F=1.8 temp °C+32.

B. Factors for converting U.S. customary units to SI metric units

Length		
inch (in)	millimeter (mm)	25.4*
foot (ft)	meter (m)	0.3048
yard (yd)	meter (m)	0.9144*
mile (mi)	kilometer (km)	1.609
mile, nautical (nmi)	kilometer (km)	1.852*
Area		
foot^2 (ft^2)	meter^2 (m^2)	0.09290
yard^2 (yd^2)	meter^2 (m^2)	0.8361
acre	meter^2 (m^2)	4,047
	hectometer^2 (hm^2)	0.4047
mile^2 (mi^2)	kilometer^2 (km^2)	2.590

TABLE 3.—*Conversion factors for SI metric and U.S. customary units of measurement*—Continued

B. Factors for converting U.S. customary units to SI metric units—Continued

To convert from	To	Multiply by
Volume		
inch^3 (in^3)	centimeter^3 (cm^3)	16.39
	decimeter^3 (dm^3)	0.01639
foot^3 (ft^3)	decimeter^3 (dm^3)	28.32
	meter^3 (m^3)	0.02832
yard^3 (yd^3)	meter^3 (m^3)	0.7646
pint (pt)	decimeter^3 (dm^3)	0.4732
quart (qt)	decimeter^3 (dm^3)	0.9464
gallon (gal)	decimeter^3 (dm^3)	3.785
	meter^3 (m^3)	0.003785
barrel (bbl), (petroleum, 1 bbl=42 gal)	meter^3 (m^3)	0.1590
acre-foot (acre-ft)	meter^3 (m^3)	1,233
	hectometer^3 (hm^3)	0.001233
Volume per unit time (includes flow)		
foot^3 per second (ft^3/s)	decimeter^3 per second (dm^3/s)	28.32
	meter^3 per second (m^3/s)	0.02832
gallon per minute (gal/min)	decimeter^3 per second (dm^3/s)	0.06309
	meter^3 per second (m^3/s)	0.00006309
barrel per day (bbl/d), (petroleum)	decimeter^3 per second (dm^3/s)	0.001840
Mass		
ounce avoirdupois (oz avdp)	gram (g)	28.35
pound avoirdupois (lb avdp)	kilogram (kg)	0.4536
ton, short (2,000 lb)	megagram (Mg)	0.9072
ton, long (2,240 lb)	megagram (Mg)	1.016
Pressure		
pound-force per inch^2 (lbf/in^2)	kilopascal (kPa)	6.895
atmosphere, standard (atm)	kilopascal (kPa)	101.3
bar	kilopascal (kPa)	100*
inch of mercury at 60°F (in Hg)	kilopascal (kPa)	3.377
Temperature		
degree Fahrenheit (°F)	kelvin (K)	[3]
degree Fahrenheit (°F)	degree Celsius (°C)	[4]

[3] Temp K=(temp °F+459.67)/1.8 [4] Temp °C=(temp °F−32)/1.8.

References

American Society for Testing and Materials, 1976, Standard for metric practice: Philadelphia, ASTM Publication E 380–76, 37 p.

This guide deals with the conversion of quantities in various systems of measurement to the International System of Units, which is abbreviated SI. It includes units most frequently used in the different fields of science and industry.

[U.S.] National Bureau of Standards, 1974 ed., The International System of Units (SI) : National Bureau of Standards Special Publication 330, 43 p.

The Survey uses this publication as the authority for definitions and nomenclature of base units, derived units, and supplementary units of the metric system. It is a translation of the French "Le Système International d'Unités" published by the International Bureau of Weights and Measures.

SIGNIFICANT FIGURES

Numerical data used in recording observations or in solving problems are seldom exact. The numbers generally are rounded off and consequently represent estimates of some true value. Not only the data but the mathematical operations or assumptions involved in the calculations are often approximate. In numerical computations, no more than the necessary number of digits should be used; to report their results with too many or too few digits may be misleading as to accuracy. To avoid surplus digits, numbers should be rounded off at the point where the figures cease to have a real meaning. Conversely, the number of significant figures may be unnecessarily reduced as a result of choosing the less desirable of several possible methods of calculation. Careful consideration, therefore, should be given to the significant digits involved in each measurement as well as to the operations performed on it.

As a general rule, the number of significant figures resulting from any calculation involving simple arithmetic operations on measured quantities should not exceed the number of significant figures of the least accurate number entering into the calculation. In performing the calculation itself, one more significant figure may be retained in the more accurate numbers than are present in the least accurate number.

The digits 1 through 9 are always significant regardless of their position in a number. The digit 0 is significant when it occurs between other significant digits but not when placed at the right or left of a number to fix the location of the decimal point, because that location may be changed by changing dimensions, for example, grams to milligrams. At the right of a number, 0 is significant if it indicates actual accuracy, but not if it is used only to complete a rounded number. For example, the number 0.0046 has only two significant figures, but 4,103 has four significant figures. In a number such as 53,200 we do not know the number of significant figures unless we know whether the zeros at the end were actually determined by experimental means. To remove this ambiguity the number may be written as 5.3200×10^4 if the zeros are significant, and 5.32×10^4 if they are not. Use of five significant figures indicates that the author knows that the two zeros have real meaning. Nonsignificant zeros should never be used at the right of the decimal part of a number. In tabulating data, an alternative is to list only the significant figures, the superfluous zeros being absorbed in the general heading, as follows:

Specimen	*Temperature* ($°C \times 10^3$)
A	1.4
B	2.0
C	1.8
D	1.2

Rounding Off Numbers

A consistent procedure should be followed in rounding off numbers to *n* significant figures. All digits to the right of the *n*th digit should be discarded, as illustrated in the following six examples of rounded numbers, each of which has only three significant figures:

Example	*Original number*	*Rounded number*
1	0.32891	0.329
2	47,543	47,500
3	11.65	11.6
4	22.75	22.8
5	18.05	18.0
6	18.051	18.1

If the first of the discarded digits is greater than 5, add 1 to the *n*th digit (example 1). If the first of the discarded digits is less than 5, leave the *n*th digit unchanged (example 2). If the first of the discarded digits is 5 and all the following digits are zero, round off to the nearest even number (examples 3–5). If the 5 is followed by any of the digits 1 through 9, add 1 to the *n*th digit (example 6).

If the difference between successive numbers is more important than the total or average, it may be desirable to round consistently in one direction all numbers in which the first dropped digit is followed by zeros only, instead of rounding to the nearest even number.

In presenting numerical data, only those digits that convey actual information should be given. The last digit should represent the uncertainty in the data. Unless stated otherwise, it is generally assumed that the last significant figure is uncertain by one unit. To illustrate, if the length of a drill core is given as 3.12 cm, it is implied that the true length is 3.12 ± 0.01 and is thus somewhere between 3.11 and 3.13 cm. If the uncertainty in the last figure is appreciably different from one unit, attention can be called to the uncertainty by expressing the measurement at 3.12 ± 0.03 cm.

Special problems arise in converting English-to-metric or metric-to-English units. These problems can be avoided if (a) the precision of the original measurement is stated and (b) the author adheres strictly to the concept of significant figures. Most readers will assume that the first-listed number represents the system used for the actual measurement, hence should not be confused by reconverting the second-listed number. Thus, the statement "500 ft (152 m)" means a precision of

"500 ± 1 ft," not the "500 ± 3 ft" that would result from converting the 152 m back to feet.

Absolute and Relative Errors

The absolute error of a number or measurement generally is defined as the numerical difference between the true value and the approximate value as given by the number or measurement. The relative error can be defined as the absolute error divided by the true value of the quantity. The true index of a measurement is expressed by the relative error, which in turn is indicated by the number of significant figures required to express the measurement. For this reason, the number of significant figures is vitally important in reporting measured or computed quantities.

The following example illustrates the difference between absolute and relative errors. Assume that the length of a carefully prepared core of rock 2 in. long has been measured to the nearest thousandth of an inch and that a mile of railroad track has been measured to the nearest foot. The absolute errors are 0.0005 in. for the core and 0.5 ft for the track, whereas the relative errors are, respectively,

$$\frac{0.0005}{2} = \frac{1}{4{,}000} \text{ and } \frac{0.5}{5{,}280} = \frac{1}{10{,}560}$$

The track measurement is relatively better.

Arithmetic Operations

A simple arithmetic operation such as addition or multiplication may affect the number of significant figures in the result. In addition and subtraction the location of the decimal point plays an important role in the retention of significant figures. The general rule can be illustrated thus: Suppose it is desired to add the numbers 120.632, 8.14, 980.3, and 1,401.0023, each number being correct to its last figure. Inasmuch as the third number listed is correct only to the first decimal place, it is meaningless to retain more than two decimal places in the other numbers. Consequently,

$$\begin{array}{r} 120.63 \\ 8.14 \\ 980.3 \\ 1{,}401.00 \\ \hline 2{,}510.07 \end{array}$$

and the result is rounded to 2,510.1, or to five significant figures. Note that only one decimal place is retained in the sum and that the number

of significant figures in the sum is less than the number of significant figures in two of the original numbers. The procedure of rounding off applies to measurements but not to whole numbers that are correct to the last digit. If the whole numbers in the example given above applied to individual persons or digits and represented counts that were correct to the last digit, they would be shown thus:

$$\begin{array}{r} 120 \\ 8 \\ 980 \\ 1{,}401 \\ \hline 2{,}509 \end{array}$$

and the total would not be rounded off.

If small numbers are added to (or subtracted from) large numbers of limited accuracy, the total should retain no more significant figures than are justified by the accuracy of the larger numbers. For example, in adding 356,000 (good to only three figures) and 1,420 (good also to three figures), the sum is 357,000, not 357,420. The figures that are dropped are within the limits of error of the larger number and are meaningless in the sum. By the same reasoning, the addition of a very large group of numbers of limited accuracy cannot produce a total more accurate than the respective items. Therefore, if several hundred objects have been weighed individually with an accuracy of three figures, the total weight of all the objects should be rounded off to three significant figures.

In subtraction, the number of significant figures in the difference may be considerably reduced if the numbers are close to each other in numerical value. Suppose 0.1189 is subtracted from 0.1204. The difference is 0.0015, which contains only two significant figures.

In the multiplication or division of two or more approximate numbers of different accuracies, the more accurate numbers should be rounded off so as to contain one more significant figure than the least accurate number. In this procedure, the error of the product is due almost entirely to the error of the least accurate number. Therefore, the final result should be given to as many significant figures as are contained in the least accurate number, and no more. As illustrations, two calculations may be given:

$$103.24 \times 0.0081 = 103 \times 0.0081 = 0.83$$

$$\frac{56.3}{2.23612} = \frac{56.3}{2.236} = 25.2$$

In computing with logarithms, no more decimals need be retained in the mantissa of the logarithm than the number of significant figures in the numerical factors that enter the computation. Thus, log 352.3 $= 2.5469$. It is sometimes easier to use logarithms directly from the tables without rounding off, but the results of computation should never be presented as being more accurate than the original data.

Examples of Misuse of Significant Figures

It is impossible to obtain a result more accurate than the data used. Thus the number of significant figures of the result cannot be greater than is justified by the least accurate number entering into the calculation. In spite of this rule, there are many examples of published data that contain an incorrect number of significant figures.

Many estimates of ore reserves are carried to as many as six significant figures—for example, 123,415 tons. Such a number gives a spurious impression of accuracy, if not a suspicion that the estimator is incompetent. To see the fallacy, it is only necessary to consider how reserve tonnages are calculated. The estimated volume, which is usually determined from drill-hole information, is multiplied by the density of the ore. At best, the volume can be determined accurately to only three significant figures, and probably to no more than two. The density of the ore may be correct to two significant figures. Consequently, the calculation of the estimated tonnage can produce no more than two significant figures. The figure in the foregoing example should be given as 120,000 tons.

Again, the depth to a geologic structure, as computed from gravity determinations, might be given as 13,016 ft. If, as is usual, this figure was calculated on the assumption of a density contrast for the ore body good to only two significant figures, the figure should be reported as "about 13,000 ft."

Reports on results of chemical analyses provide yet another illustration. Typically the results might be reported as 1061.39 for SO_4, 880.90 for Na, and 205.62 for Cl, all in milligrams per liter (mg/L). Each of these numbers contains five or six significant figures, whereas the analytical procedures used justified only two or three. Moreover, concentrations of more than 1,000 mg/L are customarily reported to only three significant figures; for concentrations between 10 and 1,000 mg/L only whole numbers are reported. It follows that the above results should be listed as 1060, 881, and 206 mg/L.

Certain other field measurements, some of them crude, are improperly reported to a greater number of significant figures than would be justified by the most refined laboratory methods. In these, as well as in laboratory measurements, care should be taken to use as many significant figures as are justified, but no more.

In some published stratigraphic measurements an unrealistic accuracy is indicated. The calculated thickness of a sedimentary formation of Tertiary age might be given as 14,633 ft, but if the top and bottom are as ill-defined as most Tertiary units, a more acceptable figure would be "about 15,000 ft." Calculations of the thickness of such rock units based upon measurements of strike and dip along a measured traverse inevitably contain many uncertainties (exact amount and direction of dip, magnetic declination, nature of exposure, and others) which are

almost impossible to evaluate and which limit the acceptable value to a few significant figures. Mining geologists have been known to pace the length of an adit but to use a steel tape to measure the last few feet, and to record the total distance in fractions of a foot. So too have stratigraphers been known to measure the poorly exposed parts of a section by hand leveling, but cliff-forming beds by tape, and then to construct a columnar section wherein some units, and the total thickness, are reported in inches or even in fractions of an inch.

Rejecting Inconsistent Erratic Data

In a series of measurements, it is not unusual to obtain one or more that differ widely from all the other measurements. The question then arises as to whether the aberrant observations should be omitted or included in further analysis of the data.

An observation should not be discarded just because it appears to be incorrect. Strange and Mather (1966, p. 15) summarize a simple method of deciding on exclusion or inclusion.

Reference

Strange, J. N., and Mather, Bryant, 1966, The significance of numbers and the reporting of numerical values: Vicksburg, Miss., U.S. Army Engineer Waterways Experiment Station Miscellaneous Paper 5–770, 20 p.

PRESS RELEASES

By Donovan B. Kelly

The writing and distribution of reports fulfill only part of the Survey's general mission to publish and disseminate information about the Nation's natural resources and natural hazards. Another product, the press release, is used regularly to communicate earth-science information to millions of people through the wide variety of print and electronic news media.

In a practical sense, press releases are good for the Geological Survey. In the course of natural events, the Survey is bound to get some bad press. A constant flow of releases can help to explain the wide range of good work we are doing and help to dilute the occasional dose of bad press and misunderstanding.

Press releases are not, however, just publicity tools. They are an integral part and means of fulfilling the Survey's mandate "to publish and disseminate information." They are the major means of reaching the larger lay audience beyond the tight circle of our fellow scientists. They force us to write and explain our technical research and findings in terms that our bosses—the general public, the Congress, and the co-operators—can understand and appreciate. For many citizens, they are the only source of information on the role of the earth sciences.

Press releases are not limited to announcing the results of new reports issued by the Information Office, part of the Director's Office at the U.S. Geological Survey National Center. Authors of Survey reports have a responsibility to keep the Information Office apprised of upcoming reports or other significant events, to help draft words when necessary, and even to issue local basic-data releases through appropriate channels as outlined in the Survey Manual (SM 500.5).

Press releases are not limited to announcing the results of new reports but can announce anything potentially newsworthy for which the Survey is the logical spokesman: new projects, changes in personnel, or the occurrence of natural events, such as floods or earthquakes, to name a few. Additional information or guidance is available from the Information Office.

The release date on the front of the release is an important part of news-media format and operations. Most editors appreciate a set date of release and will honor that date. The set date also lets the reporters know how much time they have to expand on your story before the news will break. If the story is too hot to allow lead time—such as

when you report current drought conditions—then give the date of preparation. The editors at least know then how old the story is. (If the story is even hotter—today's earthquake magnitude or flood peak—then it should probably be phoned in.)

The following example of a press release format outlines some of the needs, mechanics, and reasons for writing press releases.

United States Department of the Interior

GEOLOGICAL SURVEY

(Your address here)

(Your name here)
PHONE: (Your phone number here)

For release: (Put here a date at least 3-5 days after mailing)

or

For release: UPON RECEIPT (Prepared: Put here date of mailing)

BANG! BANG! BANG!

(Short, catchy, but honest title summarizing the hard news)

Again bang bang bang--catch the editor with the first paragraph: catch him by telling him why this press release is of interest to his readers; why the information is timely and should be used now. You have to do this with facts, not with exuberant adjectives. The editor has been around too long to be impressed by ballyhoo, and he is too busy to read paragraph after paragraph searching for the meat of the release. Catch and hold the editor with the first ten words of the first sentence, and then finish the sentence by giving credit to the U.S. Geological Survey, Department of the Interior.

Now that you have the editor's attention, expand on the news presented in the first paragraph; start filling in the particular who, why, what, when, where, or how that will convince the editor that his readers will want and need to read the hard news contained in the press release.

The second or third paragraph is a good place to acknowledge your cooperators. But don't lose the editor with a lot of backscratching.

According to most press-release writers, "By the time the editor reaches the fourth paragraph, he's looking for some single authority he can quote. Someone who can present the facts in a short pithy way as if he were talking directly to the reader. Someone who can add human interest to the release. Someone who can give the editor quotable--and believable--quotes."

(more)

2

The release should be written at a level that your wife, your teenage son, and the accountant next door can understand. Read the release aloud to yourself, to your wife, to your secretary. Can they understand your words? Write in short paragraphs. Write in short sentences. Use familiar words. Write to be read.

By now you have given the editor the heart of the story. In the remaining paragraphs you can expand on the hard news, but don't save any vital facts to last. From here on the paragraphs are more and more expendable and may be sacrificed to fit the space available.

To help prevent errors in retyping, complete your paragraphs on a page and don't split words at the end of a line. Double space the first paragraphs to give the editor room to edit and rewrite.

If appropriate, at this point you would list the title, authors, series, and number, and availability of any report: Copies of the ___-page report, "Title of Report," by Author's Name and published as U.S. Geological Survey whatever No., are available from _____.

If you have a collection of interesting facts you would like to cram into the release, run them as separate filler items at the end:

* Whenever possible, include illustrations with a release. Simplified maps and photographs showing scientists in action or visiting dignitaries are a few possibilities.

* To be fully used, a release must reach all the right editors or desks. Do not send a story just to your favorite reporter; you will lose more media friends than you will make. Do work with the Information Office to develop a good mailing list.

* If a page is to be followed by another page, put "(more)" at the bottom of the page. And finally, end the release with a mark that lets the editor know that you are done:

\# # # #

(Note to Editors: Sometimes in this space, between parentheses, there is a "Note to Editors" that might advise them of the availability of a photo or a special contact for additional information.)

REVIEW OF ENGLISH I

Survey reports must, of course, be written in "good English," in "correct English." But what constitutes "correct English"? There are many opinions and some authorities, but there is no Authority that sanctions English usage as the French Academy sanctions French usage. A sensible, simple, practical definition of "good usage" is "respected usage." That is, respected usage makes usage respectable. But then there is the difficulty of defining "respected" and "respectable."

Perhaps all we can do is review some of the precepts of grammar and composition laid down in English I. But let us note that language is an art, not a science; it has few absolutes. Even the basic "singular subject, singular predicate; plural subject, plural predicate" may have some variations: Most authors would write "A series of experiments was planned," but some authors might write "A series of experiments were planned," and retain respectability. The discreet editor would accept either usage as long as the author maintained reasonable consistency.

Most Survey authors have spoken English, after a fashion, since they were about 2 years old and have written it, also after a fashion, since they were about 6, so it may be a wounding experience when a new author learns that a critical reviewer or an editor apparently didn't understand what he wrote, may even have "changed my meaning."

The author may have had "downright facts" to report, but if he hasn't reported them in a sufficiently "plain way," his meaning may escape even experienced reviewers and editors. If the author's writing lacks clarity, it is ineffective and its message may be lost.

The first, elementary requirement for intelligibility and clarity is grammatical correctness. Correct spelling is also needed, and appropriate punctuation is a powerfully effective aid toward making the meaning clear.

We speak and write in sentences, which consist of subjects, predicates, objects if applicable, and the modifiers of these three sentence elements. In the basic relations of words within the sentence to each other there is wide recognition and acceptance of what is "right" and "wrong." These aspects of language usage, loosely called "grammar," remain almost constant. English is a living language and its vocabulary grows and changes rapidly, but the grammatical structure of the language has changed little in the six hundred years since the Prioress, the Parson, and the Wife of Bath made their pilgrimage to Canterbury. Punctuation and spelling have changed a great deal in the last six centuries, but there is now also fairly wide agreement as to what is correct and incorrect in these mechanical aspects of language, and they can be learned and applied without too much difficulty.

It should be noted, however, that any given language usage may or may not seem logical. That is, the language student cannot say, "Because 'this' is true, 'that,' which seems fully analogous to 'this,' is therefore and likewise true." There are historical etymological reasons for most current usage, but it is a fact that spelling and pronunciation are only the more obvious aspects of the apparently random illogic of modern English.

But effective writing requires more than mechanical correctness; it requires concern for phrases, sentences, and paragraphs, individually and in relation to each other. Because writing, above the level of mere mechanics, cannot be reduced to rules (IRS 2 [1962], p. 52), the reader and follower of STA 6 will not automatically become a finished writer. Facility in writing effectively is achieved in the same way as facility in any other skill: by much practice and by much attention to small details of style, of substance, and of structure; only through this practice and attention will the Survey author improve his writing. As we have implied before, one dissertation does not make a writer.

As the writer becomes more experienced, he will develop stylistic devices of his own to achieve clarity. In the meantime, he may find helpful some of the devices suggested in these pages.

Rhetorical, syntactical, and, to some extent, grammatical suggestions made herein can be only for general usage; where specific examples of inadvisable usage are given, knowing authors will probably be able to quote great English writers from Chaucer to Churchill in contradiction. Any rhetorician will say, for instance, that "It is," "There are," and "This is" are the weakest of sentence beginners and that they call for sentence rearrangement. But consider:

> There is no terror, Cassius, in your threats.
> There is a tide in the affairs of men, which, taken at the flood, leads on to fortune.
> Is there no balm in Gilead?
> This is my beloved Son, in whom I am well pleased.
> It is not only fine feathers that make fine birds.

These sentences need no rearrangement, but then Shakespeare, Saint Matthew, and Aesop were not writing Professional Papers for the U.S. Geological Survey.

The Subject and the Predicate

A basic principle of English grammar is that the predicate of each clause or sentence agrees with its subject in number. In primitive or infantile communication ("I see the dog. The dog sees me"), this concept presents no problems, but by the time the more sophisticated communicator has registered for English I his thoughts have become more complex and his communicating more difficult.

1. The predicate agrees with its subject, no matter how far the two are separated:

The toxic plants native to the floodplain pasture could make the imbalance of the trace elements worse, but has, in our opinion, made only minor contribution to the interference syndrome.

The toxic plants native to the floodplain pasture could make the imbalance of the trace elements worse, but have, in our opinion, made only minor contribution to the interference syndrome.

The unique topography of the mountain and the orientation of its sheer wall tends to inhibit rainfall.

The unique topography of the mountain and the orientation of its sheer wall tend to inhibit rainfall.

The unadjusted records of the storage gage shows the mountain area has averaged 451 inches of rain a year.

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The first of the photoimage maps of the Charleston area are expected to be available in March 1974.

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The combination of aerial photography and conventional mapping techniques provide distortion-corrected black-and-white photoimage maps.

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Earth-science research, environmental monitoring, and data-gathering is used in coping with natural-resource problems.

Earth-science research, environmental monitoring, and data-gathering are used in coping with natural-resource problems.

2. A parenthetical expression does not affect the predicate of the sentence:

A child, and perhaps also his parents, fears the unknown.

The long-standing application, and all possible consequences of its approval, have been fully examined in the final environmental impact statement.

The long-standing application, and all possible consequences of its approval, has been fully examined in the final environmental impact statement. *Or* (better): The long-standing application of the final environmental impact statement and all possible consequences of its approval have been fully examined.

Phrases introduced by "as well as," "in addition to," and "together with" are always parenthetical, whether or not set off by commas.

3. The predicate agrees with its subject, not with the predicate noun (s):

Long periods of quiet separated by major earthquakes probably is the nature of this segment of the fault.

Long periods of quiet separated by major earthquakes probably are the nature of this segment of the fault.

If the correct grammatical usage produces undesirable awkwardness, minor rewording will usually produce a more euphonious sentence.

The stony matter is largely angular blocks of limestone.

The stony matter is made up largely of angular blocks of limestone.

The large accumulations of sawdust are a serious danger.

The sandstone strata are an example of the continental deposits in that area.

The large accumulations of sawdust constitute a serious danger.

The sandstone strata form an example of the continental deposits in that area.

4. Certain noun and pronoun subjects may take either singular or plural verbs as predicates, depending on the meaning of the sentence. If the thing, group of things, quantity, distance, time, or extent represented is viewed collectively as a unit, the verb should be singular; if the items are considered separately, the verb should be plural. The following sentences are correct:

The number of men employed was greater in 1915.
A large number of the men were injured.
He thinks that 30 cents is a high price.
Three dimes were placed on the table.
About 3,000 tons was produced in 1934. ("About 3,000 tons" means a quantity weighing, in all, about 3,000 tons; it does not mean 3,000 neat parcels each containing exactly a ton.)
At this place, 30 feet of sandstone is exposed.
A series of studies was begun. (emphasis on "series")
A series of studies were made. (emphasis on the individual studies)
Several series of studies were made.
The United States protects its natural resources. (Although the term "United States" is treated as a plural in the Constitution, it is now generally used in the singular.)

"None" is singular when it means "no one," "no person," or "nobody." It is plural when it means "no persons" or "no things." "No one" may be substituted for "none" in some sentences to express the singular.

None of the mines were open.
None of the ore contains gold.
None were injured.
No one was injured. (Emphatic: Not one was injured.)

"Each" and "every" are usually singular in usage.

Each man will stand his post.
Every species is represented.

Problems with Verbs

Verbs express action or state of being. They are characterized by mood (or "mode"), tense ("time"), voice, number, and person. A subcharacteristic, governed by mood and (or) tense, is sequence.

Aside from occasional confusion about the number of the subject with which the predicate must agree, only mood and tense of verbs are likely to present problems to the Survey author. "Verbals" are another story (p. 214–217).

Mood

Of the three verb moods, indicative (expression of fact), imperative (expression of command), and subjunctive (expression of wish, uncertainty, or condition contrary to fact), only the subjunctive causes difficulty.

Molière wrote a play about a wealthy "middleclass gentleman" who, in late middle age, learned to his delight that he had been speaking prose all his life. Millions of English-speaking people have lived and died without ever knowing that they had used the subjunctive form of verbs most every day of their lives. If they were sometimes a little troubled that "If I was you" didn't sound just right, "If I were you" might sound even less right when they stopped to think about it. So they went on, perhaps becoming successful businessmen, artists, even writers (yes, even editors) and thinking vaguely, "Some day I'm going to check into that." Or maybe they even went to "Webster's International Dictionary of the English Language, Second Edition" (WNI 2) and read the definition of the subjunctive:

> Designating or pertaining to that mood of a verb which represents an attitude toward, or concern with, the denoted action or state not as fact but as something either simply entertained in thought, contingent, possible ("give sorrow tears lest the heart *break*"), or emotionally viewed as a matter of doubt, desire, will, etc. ("mine *be* a cot beside a hill"). The subjunctive mood commonly occurs in a clause "subjoined," or added as subordinate, in English often introduced by *if, that, though, lest, unless, except, until,* etc. ("If there *were* no honey, they [bees] *would have* no object in visiting the flower" *Lubbock*); otherwise it may occur independently, in wishes, commands, exhortations, etc. [WNI 2 has no inhibitions about use of italics or of "etc."] The phrases formed for English verbs by the modal link verbs *shall, should, may, might,* etc. are sometimes called *subjunctive equivalent.*"

But if the Survey author reads definitions of it and still "just does not understand the subjunctive," that confusion, of itself, probably will not hinder the progress of his career; his superiors probably "just do not understand the subjunctive" either. That being said, we offer a few comments on the use of the subjunctive.

The difficulty in understanding the subjunctive is caused largely by the fact that the only forms of the subjunctive that differ from the indicative are (a) the third person singular present, which has no "-s" ending, and (b) the other present tense form and the future tense forms, which are all expressed by "were":

> The supervisor asked that he consider (*not* considers) repeating the experiment.
>
> If he were (*not* was) certain of the outcome, he would proceed.
>
> If a similar earthquake were to occur in the central Mississippi Valley, it would probably cause severe damage.

All other subjunctive verbs have the same form as indicative verbs:

> If he had been certain of the outcome, he would have proceeded.
>
> If a similar earthquake had occurred in the central Mississippi Valley, it would probably have caused severe damage.

The subjunctive is economically meaningful when used to express a wish, an uncertainty, or a condition contrary to fact:

If that hypothesis should be correct, all our previous concepts would be invalid.
If that hypothesis be correct, all our previous concepts are invalid.
If that hypothesis were correct, all our previous concepts would be invalid.

By using the subjunctive, the writer clearly indicates that he does not believe "that hypothesis" is correct. An additional phrase would be required to indicate such doubt by means of an indicative verb:

If that hypothesis is correct, all our previous concepts are invalid—and I don't believe they are.

If the imperative mood is used, it should be used consistently where it is applicable. Don't, for instance, give some steps of a procedure in the indicative or subjunctive mood and then shift to the imperative, or vice versa. (See also "Parallel Construction," p. 236.)

Choice of tense

Verbs specify whether the action or state of being has happened (past tenses), is happening (present tenses), or will happen (future tenses). By adding appropriate auxiliaries to the main verb, the writer can identify the general time frame and sequence of occurrence:

He gave, was giving, had given, had been giving.
He gives, is giving, has given, has been giving.
He will give, will be giving, will have given, will have been giving.

Some of these active-voice verb forms have corresponding passive-voice forms:

He was given, was being given, had been given.
He is given, is being given, has been given.
He will be given, will have been given.

The following advice by an unknown author is quoted for consideration by Survey writers:

1. Experimental facts. The experimental facts should be given in the past tense. (For example: The plants grew better in A than in B: the dry weight was greater in A than in B.)
2. Presentation. The remarks about the presentation of data should be mainly in the present tense. (For example: Diagrams showing yields are illustrated in figure 3. The second column of table 2 represents the dry weight of tops.)
3. Discussions of results. Discussions of results may be in both the past and present tenses, swing back and forth from the experimental

facts to the presentation. (For example: The highest dry weight is shown for culture A, which received the greatest amount of the ammonium salt. This may mean that the amount of nitrogen added was the determining condition for these experiments.)

4. Specific conclusions. Specific conclusions and deductions should be stated in the past tense, [in order to emphasize] the special conditions of the particular experiments and to avoid confusing special conclusions with general ones. (For example: Rice grew better, under the other conditions of these tests, when ammonium sulfate was added to the soil. Do not say: Rice grows better when ammonium sulfate is added to the soil.)
5. General truths. When a general truth is mentioned, it should, of course, be stated in the present tense. Logically, a general truth is without time distinction. For example, one may say, "Many years ago, scientists were convinced that malaria is caused by a germ carried by a certain species of mosquito." General conclusions, well-established principles of mathematics, physics, and chemistry, should be put in the present tense.

Two further suggestions as to choice of tense are offered:

1. Present and past tenses should not be used interchangeably with bibliographic references, as: "Smith (1960, p. 44) reports * * *; he stated * * *." Either present or past tense is permissible, but consistency should be maintained. An easily followed plan is to use past tense for the individual, whether living or dead, and present tense for the book, map, chart, or other inanimate reference that will exist indefinitely, as: "Brown (1965, p. 261) stated, believed, implied, indicated * * *; his figure 6 shows * * *."
2. If an action or state of being was completed in the past, that fact should be made clear. If the simple past tense is applicable, use of the present perfect is confusing:

> Four units have been inferred. (The writer meant that in his field study he inferred four units, but the reader does not know whether the present writer or some previous writer inferred four units. Write "Four units were inferred.")
>
> The specific yield has been determined by two analytic methods. (By the writer or by some other researcher?)

Sequence of tenses

Verbs in simple and compound sentences have independently complete meanings, and the question of the time relation of one action or state of being to another does not arise:

> He came yesterday.
>
> He came yesterday, and they will leave tomorrow.

But when a subordinate, dependent clause is added and the sentence becomes complex or compound-complex, attention must be given to the relation, in time and logic, of the verb(s) in the dependent clause(s) to the verb(s) in the main clause(s):

We spoke to him before we knew that he had resigned.
Such data suggest that some of these faults will slip again (or "may slip again" or "have slipped before," or other).
We suggest that further research be undertaken in this area.

If an indicative or present subjunctive verb form is used in a conditional clause, any appropriate verb form may be used in the conclusion. If the condition is stated in the past subjunctive, a past subjunctive auxiliary verb is required in the conclusion:

If that is not so, I will tell you.
If that be not so, I will tell you.
If it were not so, I would have told you.
If adequate data were available, such fault slips would be predictable.
If adequate data had been available, such fault slips would have been predictable.

If the sentence has so many clauses that correct choice of tenses is perplexing, it probably is too long or too complex and should be broken up:

Smith believed that the emplacement had already occurred when the Laramide mountain-building activity began and that it therefore predated the later period of fluvial deposition but was contemporaneous with an earlier deposition, all remains of which have been eroded.

Voice

The passive voice has had a rather bad press as the "weakest part of our language" (O'Hayre, p. 61), perhaps because it occurs so frequently in what is called "governmentese" or, more irreverently, "gobbledygook." But other writers hold that "The English passive is a powerful verb form" (Evans and Evans, 1957, p. 357). A third writer says that the passive voice "is an important consideration * * * particularly in scientific writing, where the thing that has been proposed, developed, or hypothesized is often more important than the agent doing the proposing, developing, and hypothesizing" (Bell Telephone Laboratories, 1967, p. 51).

The passive voice is generally more impersonal and more formal than the active. However, the choice between the two usually depends on what the writer wants to emphasize: who (what) performed the action, or who (what) received the action.

Only one suggestion is offered: Don't change voice in midclause or in midcompound sentence; you may confuse the reader and you definitely will violate the principle of parallel construction (p. 236).

These vugs contain no gold and the tenor of the vein has not been affected by them.

These vugs contain no gold and do not affect the tenor of the vein.

The workings were closed and examination of them could not be made.

The workings were closed and could not be examined.

This series consists largely of shale though much sandstone and limestone are included.

This series consists largely of shale but includes much sandstone and limestone.

The company took over the Primrose Claim in June, and the Bluebell Claim was acquired in July.

The company took over the Primrose Claim in June and the Bluebell Claim in July.

If the connections at the tops of the bents had held, their bases would have rotated streamward as were the bases of some of the piers.

If the connections at the tops of the bents had held, their bases would have rotated streamward as did the bases of some of the piers.

The coal-bearing beds are not overlain by glacial gravel, so deeper weathering has taken place.

The coal-bearing beds are not overlain by glacial gravel, and therefore have been more deeply weathered.

The land is characterized by vast expanses of bare black rock deeply scarred by labyrinthine canyons and channels, plunge pools and rock basins, cascade and cataract ledges, and displays ragged buttes and cliffs, immense gravel bars, and giant ripple marks.

The land is characterized by vast expanses of bare black rock deeply scarred by labyrinthine canyons and channels, by plunge pools and rock basins, and by cascade and cataract ledges; ragged buttes and cliffs, immense gravel bars, and giant ripple marks are displayed.

The hybrids (verbals)

Gerunds, infinitives, and participles (usually called "verbals") are verb forms that function as other parts of speech. They give the language much of its richness, flexibility, and variety.

GERUNDS

Gerunds, the "-ing" verb forms that are used as nouns, are rather difficult to misuse, though the writer may have to decide what he wants to emphasize: He may write "I heard his singing," to emphasize what he heard, or he may write "I heard him singing," to emphasize whom he heard. The first "singing" is a gerund, object of "heard"; the second "singing" is a participle describing the pronoun "him."

Mr. Jones' singing could be heard all over the neighborhood. (gerund)
Mr. Jones, singing in his shower, could be heard all over the neighborhood. (participle)

INFINITIVES

Usage of infinitives (the "to" forms of verbs, though in some expressions the "to" may be omitted) is a little more complicated than usage

of gerunds. There's the question of "to split or not to split." Perhaps we may agree that the best writers split only when necessary to make their meanings clear, and that isn't very often. If the writer decides that a split infinitive is appropriate, he may wish to be one of Fowler's fifth class of splitters rather than one of the first four classes (1965, p. 579):

> The English-speaking world may be divided into (1) those who neither know nor care what a split infinitive is ["a happy folk," says Fowler]; (2) those who do not know, but care very much; (3) those who know and condemn ["bogy-haunted creatures"]; (4) those who know and approve; and (5) those who know and distinguish.

But do bear in mind that if an infinitive is split, the splitting adverb inexorably modifies its infinitive. The author who wrote that "The program was designed and written to specifically accommodate interactive access to data banks" must have meant "The program was specifically designed and written to accommodate * * *." (Or did he mean "The program was designed and written to accommodate interactive access to specific data banks"?)

A more difficult matter than the split infinitive is the dangling infinitive phrase. An initial infinitive phrase dangles if it does not refer to the subject of the main clause of the sentence (IRS 1, p. 110).

To evaluate the potential effects of future earthquakes, actual effects of past earthquakes must be studied.	To evaluate the potential effects of future earthquakes, we must study actual effects of past earthquakes.

PARTICIPLES, PAST AND PRESENT

Participles (verb forms that may be used as adjectives) are very useful parts of speech, but their correct usage can be tricky. In the statistics of crimes against grammar, misuse of participles must be near the peak of the curve. This misuse is so widespread and contagious it might be called "participilitis"; Evans and Evans (1957, p. 354) decreed the misuse not only respectable but necessary to those who would write "good English"!

In general, the past participle is seldom misused except by the uneducated in variations of such as "He done it," though even a postdoctoral fellow may have to consult a dictionary for the correct choice of "proved" or "proven" and may find that lexicographers themselves can give no firm dictum.

It is the present, "-ing" participle that is so easily misused when functioning as part of an adjective phrase. Such misuse occurs when the participle "dangles," that is, when its function is descriptive but the sentence contains no noun or pronoun that it can logically describe: "Where the till is thick it is light in color, indicating a lesser degree of oxidation."

The meaning of the sentence perhaps is fairly clear, but little ingenuity is needed to recast it into correct grammatical form: "The light color of the thicker till indicates a lesser degree of oxidation" or

"Less oxidation of the thick till is indicated by the lighter color" or "Where the till is thick, its lighter color indicates a lesser degree of oxidation" or some other variation. To add "thus" to a dangling participial phrase corrects nothing. "* * * thus indicating less perfect oxidation" would still dangle. "As a matter of fact, we can be pretty sure that any 'thus * * * -ing' combination in a sentence forms a dangling participle" (IRS 2, p. 54).

The present participial phrase should clearly modify the subject of the sentence or of the independent clause, or it should be close to the noun or pronoun it does modify. Correction of the dangling participle may require substitution of some other part (s) of speech.

The flood left its mark along a course of more than 550 miles, extending from western Montana to the Pacific Ocean.

The flood left its mark along a course extending more than 550 miles, from western Montana to the Pacific Ocean. *Or*: * * * extending from western Montana to the Pacific Ocean, more than 550 miles. *Or* (better): The flood extended for more than 550 miles, from western Montana to the Pacific Ocean.

Mt. Waialeale has an average rainfall of 451 inches a year, making the peak the wettest known spot on earth.

Mt. Waialeale, which has an average rainfall of 451 inches a year, is the wettest known spot on earth. *Or*: Its average rainfall of 451 inches a year makes Mt. Waialeale the wettest known spot on earth. *Or*: Mt. Waialeale has an average rainfall of 451 inches a year; it is the wettest known spot on earth.

The unique topography of the mountain tends to concentrate and wring most of the moisture out of the prevailing trade winds, leaving little moisture for areas in the rain shadow of the mountain mass.

The unique topography of the mountain tends to concentrate the moisture and wring most of it out of the prevailing trade winds; little moisture remains for areas in the rain shadow of the mountain mass.

Having only horizontal layers in the model, lateral movement could be measured only by noting the relative thinning or thickening between dark layers.

Because there were only horizontal layers in the model, lateral movement * * *

The lunar avalanches suggest that avalanches can behave like fluids composed of rapidly moving particles, allowing the avalanches to move for long distances and at great speeds.

The lunar avalanches may behave like fluids composed of rapidly moving particles; if so, they can move for long distances and at great speeds.

The science of logic has a useful term, "non sequitur," to apply to a stated consequence that does not logically follow from the premise. The term can also be used for parts of certain sentences that begin with participial phrases. The participial phrases in the following sentences

modify the subjects in the main clauses as required, but have no relation to them in logic:

Going forward on all fronts, the army was composed of many divisions.
Ostracized for his bohemian bachelor life, he suffered from eye trouble in his later years.
Containing 17 tables and illustrations, the report is the latest in the Survey's "Water in the Urban Environment" series.
Used as construction material and in Portland cement, the demand for crushed limestone is increasing.

Some words that are derivatively present participles have come to be accepted by the strictest grammarians as suitable for independent usage. They may perform the function of prepositions, as "following" (in the sense of "after"). Phrases beginning with "according," "barring," "concerning," "considering," "failing," "granting," "notwithstanding," "pending," "speaking," and a few other "-ing" participles may also be exempted from the requirement that they modify a noun or pronoun. Most of these words are parts of set idiomatic phrases ("according to," "speaking of," "turning to," "depending on") that are sometimes called "double prepositions," "phrasal prepositions," or "participial prepositions."

A participial phrase that modifies the whole sentence but is grammatically independent of it (usually called a "nominative absolute") is correct grammatically, but such a phrase may make for an awkward sentence:

The difficulties being by no means insuperable, a satisfactory interpretation may be worked out.

Because the difficulties are by no means insuperable, a satisfactory interpretation may be worked out. *Or*: A satisfactory interpretation may be worked out, inasmuch as the difficulties are by no means insuperable.

The light, oval grains being an eighth of an inch in diameter, they were highly visible against the dark background.

The light, oval grains were an eighth of an inch in diameter and therefore were highly visible against the dark background.

Adroit Use of Modifiers

The subject, predicate, and object are the skeleton frame of the sentence. The modifiers, that is, the adjectives, adverbs, participles, and descriptive phrases and clauses, skillfully used, give the sentence rich detail and explicit meaning.

Two suggestions are strongly urged in use of modifiers: Choose the best words available to express your meaning and then put them in the most appropriate places. Writers are sometimes exhorted to use the "exact" word to express their meaning or to use words of "exact" meanings. Actually, few words have "exact" meanings. Dictionary definitions of some of the most commonly used words may occupy a full column

of 6-point type. Only when adroitly used in relation to each other do words acquire "exact" meanings.

To help him in choosing the "best words available," the writer needs access to an unabridged dictionary and to relevant glossaries, lexicons, and gazetteers. If he has time to pursue the fine points of semantics, there are many word-usage books to help him. A few such helps are listed beginning on page 28; as noted there, the "usage" books contain much fascinating information on the history of the language and the meanings of its words; they also contain some of their authors' personal preferences and prejudices with which other language authorities may not agree.

Suggestions on usage of a few words and phrases are included in this book under "Suggestions as to Expression (p. 239)."

"The most appropriate places" for modifiers are usually as near as possible to the particular words, phrases, or clauses they modify.

Possible effects of misplaced or misworded modifiers range from clumsy to confusing.

In Indiana recent writers have classified the rocks as Utica or Eden.	Writers have recently classified the rocks in Indiana as Utica or Eden.
Fossils were described from Indiana.	Fossils from Indiana were described.
Care should be taken to see whether such wells are contaminated by frequent analyses.	Frequent analyses of the water should be made to see whether such wells are contaminated.
The luxuriant gray green of the sagebrush * * *.	The gray green of the luxuriant sagebrush * * *.
Tilted edges of s a n d s t o n e strata * * *.	Edges of tilted s a n d s t o n e strata * * *.
The most prevalent region of cloudbursts * * *.	The region of most prevalent cloudbursts * * *.
A coarsely porphyritic rock of dark granular texture * * *.	A coarsely porphyritic dark rock of granular texture * * *.
A FORTRAN program has been written for computing estimates of gradients on the USGS IBM 360/65 and CalComp plotter.	A FORTRAN program for computing estimates of gradients has been written for use on the USGS IBM 360/65 and CalComp plotter.
Knowledge of regional geology is not sufficient in most parts of the country to identify all favorable geologic environments.	Knowledge of regional geology of most parts of the country is not sufficient to identify all favorable geologic environments.
Then the party went up the Kaolak in canoes to its head.	Then the party went in canoes up the Kaolak to its head.
The well had been drilled by the turn of the century.	By the turn of the century, the well had been drilled.
Two altered thin vitreous tuff beds * * *.	Two thin beds of altered vitreous tuff * * *.
The information has been slow and cumbersome to extract.	Extraction of the information has been slow and cumbersome.

In general, a word or phrase that applies equally to two or more items should be given with the first and not with the last:

The terrain is mountainous in the western part and level in the eastern part of the quadrangle.	The terrain is mountainous in the western part of the quadrangle and level in the eastern part.
The thickness ranges from 700 feet at the east side to perhaps 1,600 feet at the west side of the area.	The thickness ranges from 700 feet at the east side of the area to perhaps 1,600 feet at the west side.
The upper coal bed is as thick, if not thicker than the lower.	The upper coal bed is as thick as the lower, if not thicker.

But if a preceding modifier does not apply to all of the following phrase, insertion of the article "the" or "a" may clarify the meaning:

The child had a red and green apple.	The child had a red and a green apple [if the child had two apples]. Better: The child had a red apple and a green apple.
The formation consists of a calcareous and arenaceous series.	The formation consists of a calcareous and an arenaceous series.

Even otherwise unmodified nouns may need individual "the's," "a's," or other adjectives for clarity:

> The secretary and the treasurer came to the meeting.
> My packer and my driver accompanied the mapping party.

A reversal of word order may avert smiles from alert readers:

The structures range from high-rise buildings and dams to * * *.	The structures range from dams and high-rise buildings to * * *.

Participal modifiers are discussed under "Problems with Verbs" (p. 215–217).

"Strung-on" modifiers

"Strung-on" modifiers occur frequently in stratigraphic and mineralogic descriptions. The authors of the Bell Telephone Laboratories editorial guide (1967, p. 7) note that in "technical writing it is customary to precede the noun * * * with all the necessary restrictive adjectives so that the item is precisely defined before the verb is mentioned." And, they concede (p. 7–8), "for specification adjectives this is an effective sequence. But for other types of descriptive material, the established convention of the English Language—the use of prepositions and relative clauses—is more effective * * *. [Instead] of aiding clarity, strung-on modifiers may hinder it by compressing and crowding thoughts too severely. The astute author * * * will be aware that when he wishes to emphasize any aspect or attribute, the phrase or interpretive clause will better serve his purpose."

"A comprehensive draft environmental impact statement has been released for public comment" would more effectively be written "Draft of a comprehensive environmental-impact statement has been released

for public comment," *or* "A comprehensive environmental-impact statement in draft form has been released to the public for comment."

Placement and form of adverbs

Emphasis and other fine distinctions of meaning can be obtained by careful placement of adverbs:

Happily, that possibility had been anticipated.
That possibility had, happily, been anticipated.
That possibility had been happily anticipated.

The intended meaning or emphasis and the rhythm of the sentence will generally be adequate guides to positioning of adverbs; however, Follett (1966, p. 50–55) gives detailed and practical advice on the subject and also on other aspects of adverb usage; he flatly disagrees with the sometime tenet that the parts of a compound verb must not be separated by an adverb.

Some adverbs have two correct forms, one the same as the adjectival form, the other the more common adverbial "-ly" form: "loud" or "loudly," "quick" or "quickly," "high" or "highly." The two forms of some of these adverbs have differences in idiomatic meaning or use:

Drive slow *or* Drive slowly; *but* We slowly climb the mountain, *not* We slow climb the mountain.
We climbed high on the mountain.
The other group was highly critical of that theory.

Pronouns

Pronouns are characterized by case (subjective, objective, or possessive), number (singular or plural), and person (first, second, third, or impersonal). They refer to a noun (or another pronoun), which is called an "antecedent." The antecedent is usually stated, but it must at least be clearly understood. Pronouns may or may not agree with their antecedents in case, depending on the use of the pronoun in the sentence, but they are inflexibly required to agree with their antecedents in number and person.

Some problems in use of pronouns arise from these requirements for antecedents and for agreement with them. Such difficulties lead to the following comments, suggestions, and warnings:

1. Not only must a pronoun have an antecedent, stated or understood: The sentence structure must be such that no ambiguity exists as to what is the antecedent. Lacking other clues, the reader tends to refer a pronoun to the nearest suitable noun, but only the student of ancient history can be certain "whose major export was iron" in the sentence "The Etruscans, a wealthy trading

people like the Greeks and Phoenicians, whose major export was iron, reached their heyday in the 7th and 6th centuries B.C."

The pronoun subject of a beginning subordinate clause must refer to the subject of the main clause, or risk chuckles from readers:

While he was still in his teens, his grandfather offered him a trip abroad.

Use of the indefinite "this" or "which" to refer to a whole preceding thought should, in general, be avoided. Ask yourself "This what?" or "Which what?"

The lava-tube system was blocked, which stopped the flow of lava into the ocean and resulted in new surface flows.

Blockage of the lava-tube system stopped the flow of lava into the ocean and resulted in new surface flows. *Or*: The lava-tube system was blocked; this blockage stopped the flow of lava into the ocean and resulted in new surface flows.

If per capita consumption were to continue to increase as it has in the last few decades, total requirements would be two to three times larger. This dramatizes the three major challenges facing the nation.

If per capita consumption were to continue to increase as it has in the last few decades, total requirements would be two to three times larger. This potential increase dramatizes the three major challenges facing the nation.

The ground cracks commonly extended 500 feet back from streams, which indicates that landspreading occurred over large areas.

The ground cracks, which commonly extend 500 feet back from streams, indicate that landspreading occurred over large areas.

Erosion and cataract retreat removed the basalt flows. This exposed the granitic rocks * * *

Erosion and cataract retreat removed the basalt flows. This removal exposed * * *. *Or*: Erosion and cataract retreat removed the basalt flows and thus exposed * * *.

Note: When "this" or "these" is used as an adjective, the requirement for a clearly recognizable antecedent still holds:

During early Tertiary time an area beneath the present mountains was arched, possibly by a deep-seated intrusion. This dome * * *. (No dome has been mentioned; change "This dome" to "The dome thus formed.")

2. Beware of confusing repetitions of "it." Avoid using "it" the expletive and "it" the indefinite personal pronoun in the same sentence.

It has not been possible to identify it with any of the described forms, and it seems to be so distinct that it is probable that additional examples could be recognized without difficulty.

It could not be identified with any of the described forms, but it seems to be so distinct that additional specimens probably could be recognized without difficulty.

It was the force of the water draining from the lake in three giant rivers that raced across the vast lava field, that carved and shaped the land into its present forms.

The water, draining from the lake in three giant rivers, raced across the vast lava field and carved the land into its present forms.

3. Beware the intensive pronouns ("myself," "yourself," "himself," "herself," and their plurals). Be sure they have an antecedent to intensify: Wrong: The landslide was witnessed by the leader of the party and myself. Also wrong: The leader of the party and myself witnessed the landslide. Correct: I myself witnessed the landslide. *Or*: I myself, together with the leader of the party, witnessed the landslide. *Or*: The leader of the party and I witnessed the landslide.
4. A pronoun refers to the adjectives modifying its antecedent as well as to the antecedent itself:

> The basal beds rest unconformably upon those of the Fort Union Formation. (Delete "those of.")
>
> Probably less than two dozen cottonwood trees occur along the San Juan at and below Piute Farms, yet they are numerous in some of the side canyons. (The antecedent of "they" is "less than two dozen cottonwood trees"; change "they" to "cottonwoods.")

5. The proper choice of "who" or "whom" can be confusing. The conjunctive, or relative, pronoun is always either the subject or the object of the verb in the subordinate clause it introduces; it is never the object of a preceding preposition or verb. The following examples illustrate correct usage:

> The man who was the one I saw leaving the scene of the crime * * *.
> The man whom I saw leaving the scene of the crime * * *.

The confusion can often be avoided by using "that":

> The man that was the one I saw leaving the scene of the crime * * *.
> The man that I saw leaving the scene of the crime * * *.

6. In references to himself, the author should maintain consistency in any one report. Either "the author" or "the writer" is correct, but use of both can be ambiguous. The indefinite "one" is a respectable semantic nicety, but in American usage is rather stilted—it brings to mind the elegantly extended little finger. If the author wishes to avoid "the writer," "the author," and "one" but his modesty forbids "I," perhaps an authorial "we" (that is, "my hammer and I," or "my microscope and I," or "my computer and I") might be considered. And if he cringes from addressing the reader as "you," he might write "the reader," or "the scientist," or some other indefinite form of address. But if "one" is used, it should be used consistently:

> If one wishes, one can break up the tour to rest or have a meal and then rejoin another one at the point where you left off. Or you can skip the tour entirely and go right up to the bar.

Fowler (1965, p. 401–404) has some strong opinions about the use of "one" as a personal pronoun.

Punctuation, Its Uses and Power

A speaker uses gestures, facial expressions, and voice tone and inflection to help make clear the meaning of his words. A writer uses punctuation for the same purpose.

Punctuation was invented to clarify the meaning of written words, and it is a powerful instrument toward that end. Addition or omission of a comma, for instance, can make a fine but vital distinction in the meaning of a phrase. Consider:

Additional voluntary contributions * * *.
Additional, voluntary contributions * * *.
He performed his duties fairly conscientiously, and also effectively.
He performed his duties fairly, conscientiously, and also effectively.
Mary Sue and Jim
Mary, Sue, and Jim

Consider also:

Mr. Smith's secretary
Mr. Smith's "secretary"
I saw him.
I saw him!
I saw him?
18 gallon jugs
18-gallon jugs

Punctuation was invented long after writing. Most punctuation marks in common Western usage today have become common since the advent of the printing press. Greek and Roman scrolls might or might not have periods (or "stops") at the end of sentences, but they might also have what we would call a period between each word. Words on the eleventh-century Bayeux tapestry are separated by two periods, one above the other, which we would call a colon.

Punctuation (a) groups related words, (b) separates unrelated words, (c) encloses parenthetical words, and (d) emphasizes important words. Like other aspects of language usage, punctuation has few absolutes. Its usage is purely functional; its only purpose is to make the intended meaning clear. Survey punctuation usage is based on the GPO style manual (1973, p. 131), whose usage in turn is based on the principles (a) "that if it does not clarify the meaning it should be omitted" and (b) "that in the choice and placing of punctuation marks the sole aim should be to bring out more clearly the author's thought." If a sentence cannot be so punctuated as to make the author's thought clear, the sentence probably needs to be rephrased.

The comma

1. A comma is needed after any introductory phrase or clause if its absence requires the reader to back up and reread the sentence to understand the intended meaning:

During periods of intense rain water from the claypit area flows through this ranch.

During periods of intense rain, water from the claypit area flows through this ranch.

Where data are inaccurate or insufficient deviations from expected results occur.

Where data are inaccurate or insufficient, deviations from expected results occur.

2. An introductory participial phrase should be set off by a comma:

Spreading toward natural and manmade depressions, the sediments settled in stream valleys, drainage ditches, borrow pits, and lakes.
Deflected by natural obstructions, the lava stream turned eastward.

3. Commas are required between the parallel words, phrases, or clauses of a series:

The deposit consists of clay, sand, and gravel.
The upper coal is 21 inches thick, the parting 12 inches, and the lower coal 18 inches.

If the members of the series contain commas, a semicolon between the members may be needed for clarity:

The order of deposition was: quartz and pyrite; massive galena, sphalerite, and pyrite; brown carbonates and quartz; and small amounts of all those named, together with fluorite, barite, calcite, and kaolin.

4. Commas are needed between two or more adjectives of equal rank (parallel, or coordinate, adjectives) that precede the word (s) modified. (If "and" can be inserted between the adjectives or if their order can be reversed with no change in meaning, then the adjectives are parallel and should be separated by a comma.)

Parallel	*Nonparallel*
hard, impermeable subsoil	hard clay subsoil
a brief, interesting account	a brief typewritten account
dark, fertile loam	dark sandy loam
short, swift streams	short tributary streams
long, tedious spell of dry weather	long dry spell
freezing, driving rains	yellowish-gray clayey sand
perceptible, strong ground motion	homogeneous earthy material
handmade, small-scale wooden model	heavy spring rains
open, wood trestles	strong lateral ground motion
	small-scale low-angle thrust model
	multiple wood trestles

5. Parenthetical words, phrases, and clauses are usually set off by commas. Parentheses or dashes may be used to indicate stronger,

longer, or more abrupt breaks in thought; they are also used, rarely, to enclose parenthetical expressions that include other punctuation. Parentheses within parentheses should be avoided except when required for reference identification, for queried stratigraphic names, or for paleontologic uses.

The enclosing punctuation marks are needed on both sides of the parenthetical expression and must be in identical pairs: two commas, for instance, or two dashes—not a single comma or a comma and a dash.

Several individual flows, each thicker than 75 feet have been traced for more than 100 miles.

Several individual flows, each thicker than 75 feet, have been traced for more than 100 miles.

The President, in his energy message to the Congress recommended that this program go forward.

The President, in his energy message to the Congress, recommended that this program go forward.

Several California cities, especially in the San Francisco Bay region and in the greater Los Angeles area are so located.

Several California cities, especially in the San Francisco Bay region and in the greater Los Angeles area, are so located.

Most geologists agree that the lands were carved by the "Spokane Flood"—the greatest flood documented by man, that took place 18,000 to 20,000 years ago during the Great Ice Age.

Most geologists agree that the lands were carved by the "Spokane Flood"—the greatest flood documented by man—that took place 18,000 to 20,000 years ago during the Great Ice Age.

Expressions introduced by "together with," "as well as," and "in addition to" are usually set off by commas; that is, the expressions are parenthetical and do not affect the predicate of the sentence. (See "The Subject and the Predicate," p. 207.)

Commas are needed between more than two items of run-in numbered or lettered series:

Damage resulted from (a) * * *, (b) * * *, (c) * * *, and (d) * * *

6. The independent clauses of a compound sentence may or may not need separation by commas or semicolons, depending on their length and complexity, but the coordinate conjunction "for" needs a preceding comma to avoid being read as a preposition. If "because" is used instead of "for," the comma may not be needed.

The arching of the deck probably pulled the piling upward for the connections between the stringers and the piles were strong.

The arching of the deck probably pulled the piling upward, for the connections between the stringers and the piles were strong. *Or*: The arching of the deck probably pulled the piling upward because the connections * * *

7. No punctuation is needed after items in a vertical list, whether numbered or unnumbered, unless the items are complete sentences or clauses:

During our trip we saw many interesting sights:
Washington Monument
Statue of Liberty
Mount Vernon
Natural Bridge
Lee's birthplace
Shenandoah Valley

But:

$$P=\tfrac{1}{2}\gamma H^2 Kp,$$

where

P is force per horizontal foot of bulkhead,
γ the unit weight,
H the height along the bulkhead,

and

Kp the passive pressure coefficient.

8. A comma is needed between an adjective and an adverb modifying another adjective or a participle:

Standard, nationally recognized units of measure * * *.

9. A secondary clause beginning with "so," "then," or "yet" probably needs separating punctuation, and a comma may be sufficient. (But see comments on conjunctive adverbs, p. 229.)
10. A comma may indicate an omitted word or words: "Then we had much; now, nothing." However, this sentence could also have been correctly written thus: "Then we had much, now nothing."
11. The GPO style manual (1973, p. 136–137) and Survey style specify the following use or omission of commas in relation to dates, names, places and numbers; more examples of use or omission of commas with numbers are given in the section on "Numerals" p. 90.

Wilmington, Del., was the site of the convention.
July 4, 1776, was the date.
July 1776 was the time.
The floods occurred in June and July 1975.
The flood occurred between March 6 and April 15, 1975.
The address of the National Center is 12201 Sunrise Valley Drive, Reston, VA 22092.
Water-Supply Paper 2022, page 2632 (This usage applies to all serial numbers.); *but,*
2,632 pages, 57,480 miles
Henry Smith, Jr., chairman; John Smith II

12. Most introductory adverbial clauses and verbal phrases should be set off by commas:

Where the sediment thickness is great, sand is more common than gravel.

But,

> Sand is more common than gravel where the sediment thickness is great.

13. An initial adverbial phrase that immediately precedes the subject usually needs a separating comma (see No. 1 above):

At all bridges but one net compression exceeded net extension.	At all bridges but one, net compression exceeded net extension. *Or*: At all bridges but one the net compression * * *.

14. An unneeded or a misplaced comma can be as confusing as an omitted comma. Kierzek and Gibson (1965, p. 332–335) point out that commas "should not be so used as to separate a subject and its verb, a verb and its object, a preposition and its object, an adjective and its noun." (The interposition of a parenthetical expression is not considered a separation.) The comma in the following sentence separates a subject and its verb:

> A national program aimed at reducing hazards to life and property and at minimizing disruption of governmental and private activities, is spelled out in a newly published report. (Either insert a comma after "program" or delete the comma after "activities.")

Compound predicates and compound complementary infinitives, each consisting of no more than two elements, generally need no commas. The commas in the following sentences should be omitted.

> The Center staff also provides assistance to users, and conducts training courses in remote sensing.
>
> The final statement was filed with the Council of Environmental Quality, and was made available to the public in June.
>
> Scientific personnel are available to answer queries, and to explain how the Survey conducts mapping investigations.

Note: Skillin, Gay, and others (1974, p. 184–206) give an exhaustively detailed and profusely illustrated discussion of the uses and nonuses of the comma.

The period

Periods are most commonly used at the end of a declarative sentence, after a letter or number denoting an item in a vertical series, after abbreviations unless otherwise specified, in decimal fractions, and after the captions of text illustrations (but not after map or plate titles). They are also used in certain aspects of typographic style; the text editors will supply these periods.

The semicolon

The semicolon is a useful punctuation mark, but battles have been fought over its correct usage. One school of thought holds that it should be reserved for separation of independent clauses that are closely related in context and that would otherwise have to be put in separate sentences, where the meaning might be ambiguous. The other, and currently more numerous, school uses semicolons to separate clauses and phrases that contain internal punctuation, sometimes with a result such as:

> The intensive destruction and the loss of life at Managua, Nicaragua, during and after the December 23, 1973, earthquake were caused by the occurrence of the main earthquake and most aftershocks directly beneath the city; displacement of land surface on active faults through the city; and poor behavior of structures during strong seismic shaking, according to Survey scientists.

Such punctuation restricts the "according to Survey scientists" to the last phrase, whereas all the information in the sentence probably came from the Survey scientists. A possibly better usage would have been:

> According to Survey scientists, the extensive destruction and the loss of life at Managua, Nicaragua, during and after the December 23, 1973, earthquake were caused by (a) the occurrence of the main earthquake and most aftershocks directly beneath the city, (b) displacement of land surface on active faults through the city, and (c) poor behavior of structures during seismic shaking.

Further examples of undesirable use or nonuse of semicolons and of suggested better usage:

Brown conducted the geologic field investigation of surface fault movement; and he has been active in earthquake research for many years.

Brown, who conducted the geologic field investigation of surface movement, has been active in earthquake research for many years. *Or*: Brown, who has been active in earthquake research for many years, conducted the field investigation of surface fault movement.

In late 1971, an eruption broke out and lava advanced from fissures extending down Kilauea's southeast rift; the first eruption along this rift in 50 years.

In late 1971, an eruption broke out and lava advanced from fissures extending down Kilauea's southeast rift; the eruption was the first along this rift in 50 years. *Or*: In late 1971, the first eruption along Kilauea's southeast rift in 50 years broke out and lava advanced from fissures extending down this rift.

A program of $2 million is proposed to appraise the geothermal resource potential of public lands; and develop a variety of techniques to provide accurate assessment of the potential of this valuable source of energy, water, and minerals which could have a significant impact for the nation.

A program of $2 million is proposed to appraise the geothermal resource potential of public lands and to develop a variety of techniques to provide * * *.

If a conjunctive adverb is used between coordinate clauses without a coordinate conjunction, the adverb is usually preceded by a semicolon; however, the second clause may be written as a separate sentence for emphasis: "The mine was idle for many years; then a new company reopened it." But, if preferred: "The mine was idle for many years; and (*or* but) then a new company * * *," *or* "* * * for many years, and then * * *," *or* "* * * for many years. And then * * *."

The more common conjunctive adverbs are listed below; an exhaustive list is given in IRS 2 (p. 135–136).

accordingly	hence	nevertheless
besides	however	still
consequently	moreover	therefore
furthermore		

Brackets

Except for use in mathematical equations, where they indicate that enclosed matter is to be treated as a unit, brackets are used almost exclusively in Survey writing to enclose authorial or editorial interpolations that are not part of original quoted matter.

Parentheses

In Survey writing, parentheses are used mostly for enclosing identification of bibliographic and illustrative references. They may be used to enclose parenthetical expressions if a sharper break is needed than commas would provide or if the parenthetical expression is lengthy and includes internal punctuation.

If the matter in parentheses consists of more than one paragraph, each paragraph should begin with a parenthesis; the closing parenthesis should be placed at the end of the last paragraph.

Parentheses are used to enclose the numbers or letters identifying items of a run-in series.

The dash

As a punctuation mark, the dash is used to "mark a sudden break or abrupt change in thought" and "instead of commas or parentheses, if the meaning may thus be clarified" (GPO, 1973, p. 138). The dash should not be used as a substitute for the effort needed to construct a coordinated sentence; it is seldom needed for punctuation of Survey reports. Dashes of various widths are used as typographic devices in the printed reports; these dashes will be supplied by the text editors.

Quotation and ellipsis marks

In Survey style, quotation marks are used to enclose direct quotations, titles of publications named in text, words spoken of as words, letters spoken of as letters, words used ironically or out of context, and misnomers.

If the quoted matter consists of more than one paragraph, quotation marks should be placed at the beginning of each paragraph and at the end of the quotation. The editor will remove the quotation marks and will mark the matter for type smaller than that of the rest of the text.

The author is free to omit nonpertinent parts of quoted matter, the omission being indicated by ellipsis marks (* * *), but the result should be complete sentences:

> The great San Francisco earthquake produced a similar observation by Adams and others (1907, p. 341), who stated that "on marsh land near the Bay Shore * * *. During the quake the channel of the creek disappeared, its bottom having been raised to the general level of the adjoining land."

> The great San Francisco earthquake produced a similar observation by Adams and others (1907, p. 341) who stated that during the quake "on marsh land near the Bay Shore * * * the channel of the creek disappeared, its bottom having been raised to the general level of the adjoining land."

Omission of a complete paragraph should be indicated by a line of seven asterisks across the page.

Matter following "entitled," "the word," "the term," "marked," "designated," "classified," "named," and "signed" is usually enclosed in quotation marks. Matter following "known as" and "so-called" is usually not enclosed in quotation marks.

> The term "silt" refers to rock particles of a certain size range but is sometimes used incorrectly for all clastic sediment; the so-called bottom load, or bed load, refers to the larger particles which move on or near the bed of the stream and are not continuously in suspension.

The GPO style manual (1973, p. 145) gives further examples of appropriate usage of quotation marks:

> After the word "treaty," insert a comma.
> Of what does the item "miscellaneous debts" consist?

The document will be marked "Exhibit 21"; *but* The document may be made exhibit 2.
The check was endorsed "John Adamson."
It was signed "John."
Beryllium is known as glucinium in some European countries.
The so-called investigating body met * * *.

Quotation marks should not be used in lieu of apology—to say, in effect, that the word probably isn't the best for the place, but the writer doesn't have time to find the more suitable word. Nor should they be used with condescension—to indicate that the writer himself knows the word isn't quite right, but fears the reader may not know if he isn't tipped off.

"The comma and the final period will be placed inside quotation marks. Other punctuation marks should be placed inside the quotation marks only if they are a part of the matter quoted" (GPO, 1973, p. 146).

Spelling

The Survey in general follows, first, the GPO style manual and, second, WNI 3 for spelling and also for word compounding, capitalization, and punctuation. The GPO manual follows WNI 3 quite closely for spelling, not so closely for word compounding.

Some abbreviations, signs, and symbols commonly used in Survey reports are given on pages 99–108.

English is not an accented language, but a few borrowed words in fairly common use retain their accented forms in spelling as well as in pronunciation: mélange, précis, and résumé, for example. For most of these words, typing and typographical difficulties can be avoided by using English equivalents: mixture, abstract, and summary.

Diacritical marks are not used with borrowed words that have been completely anglicized: debris, depot, facade, material, for example.

Rules governing English spelling, including the effects of various prefixes and suffixes on the root words, are given in detail in the front of WNI 3; the rules as given there include exceptions, variants, and some British usage. Abridged rules are given in some other references; see, for example, Skillin, Gay, and others (1974, p. 469–481). See also the GPO style manual (1973, p. 61–71); rules for formation of the possessive are given in the manual chapter on "Punctuation" (p. 131–133).

Compounding

The device of combining two or more words to make the meaning clearer is as old as language. In English the practice goes back to the earliest Anglo-Saxon and classical beginnings of the language. Most

words of our present oral and written vocabularies are combinations of simpler roots:

"Woman" is from *wif* (female) plus *mann* (human being, man)—"female man."
"Husband" is from *hus* (house) plus *buan* (to dwell, to hold)—"householder" (or perhaps "housebound," as opposed to one who roams?)
"Geology" is from *ge* or *geo* (earth) plus *logos* (word, discourse)—"earth discourse," or "earth knowledge."
"Cartographer" is from *carte* (map; more anciently "paper") plus *graphein* (to write) plus *-er* (he who)—"he who writes a map."

Thousands of common English words are of fairly recent and recognizably compound origin:

bookkeeper	overburden
Congressman	powerplant
fieldwork	something
footnote	standpoint
limestone	topmost
outcrop	underground

Compounding by hyphenation has come into wide use since the invention of printing, and it is now a sort of halfway step in the evolution of compound English words: Two or more words are frequently used together to express a unitary thought; some writers and editors begin joining the words with hyphens; eventually the words are run together as one word and go into dictionaries thus. "Word forms constantly undergo modification. Two-word forms often acquire the hyphen first, are printed as one word later, and not infrequently the transition is [directly] from the two- to the one-word form * * *." (GPO style manual, 1973, p. 73).

Hyphens are also a valuable tool in clarifying the meaning of multiple modifiers. Consider:

feminine clothing store owner
feminine-clothing store owner
feminine clothing-store owner

and

the Survey's national earthquake monitoring network
a Survey automatic electronic water monitoring device

Strategically placed hyphens would avoid momentary questions as to whether there are "national earthquakes" and "electronic water."

However, multiple compound adjectives, such as those illustrated below should be used with restraint in text (see also "Strung-on Modifiers," p. 219). These modifiers break the continuity of the sentence while the reader waits expectantly for a significant noun to arrive. Some of the examples shown, or similar constructions, may be suitable in tabular work, where rigid space limitations must be observed.

alcoholic copper acetate ammonia-solution method
west-border-of-Bear-Valley report
large 4- to 14-foot-wide bodies of milling ore
425-foot-well water
300,000-kilowatt 70-percent annual-capacity factor basis
an only 2- to 3-mile-wide schist band
primitive moonlike-earth volcanism
buff and pale-gray finely and medium-crystalline generally thin-bedded (2 to 18 inch) dense, hard dolomite

Use or need of the hyphen is often a matter of opinion, but the Survey suggests the following guidelines, adapted largely from the GPO style manual rules (1973, p. 73–80).

1. Words combined to form a unit modifier immediately preceding the term modified are generally hyphened.

fire-tested material	thin-bedded limestone
fire-clay deposit	red-bed facies
drought-stricken area	bluish-gray shale
flood-plain deposits	light-green clay
ground-water study	blue-green algae
surface-water study	water-table divide

2. If the first element of a two-word unit modifier is a comparative or superlative, the phrase is written without a hyphen.

better drained soil	larger sized grains
highest priced coal	best preserved specimen

3. A two-word unit modifier is written without a hyphen if the first word is an adverb ending in "-ly"; a three-word unit modifier is written without hyphens if the first two words are adverbs.

unusually swift stream
well-defined curve
very well defined curve

4. In stratigraphic sections, well logs, and similar lists, unit modifiers follow the noun they modify and are hyphened according to the rules used when they precede the noun.

Sandstone, bluish-gray, coarse-grained, minutely shattered * * *.
Sandstone, dark-gray, thick-bedded, fine-grained * * *.

5. A chemical term used as a unit modifier is not hyphened:

calcium bicarbonate water

6. If the second element of a compound predicate adjective is a present or past participle, no hyphen is needed.

The sandstone is ledge forming.
The land is used for cattle raising.
The area is drought stricken.
The sandstone is fine grained.

The limestone is contact metamorphosed.
The coal is high priced.

7. Combining forms, prefixes, and suffixes do not ordinarily require a hyphen. Some exceptions are noted below.

Use a hyphen with the prefixes "ex," "self," and "quasi."

ex-governor	quasi-academic
self-control (selfsame is exception)	

Unless usage demands otherwise (as in "transatlantic"), a hyphen is used to join a prefix or combining form to a capitalized word.

un-American	mid-April

Except after the short prefixes "co," "de," "pre," "pro," and "re," which are generally written solid, a hyphen is needed to avoid doubling a vowel or tripling a consonant, or to prevent mispronunciation or a change of meaning.

anti-inflation	re-treat (treat again)
co-op, *but* cooperation	un-ionized (not ionized)

Words ending in "like" are not hyphened except to avoid doubling a vowel or tripling a consonant or when the first element is a proper name.

lifelike	December-like
ball-like	

8. A compound color term is not hyphened unless the term becomes a unit modifier.

The shale is olive green to blue green.
The clay beds are brick red and chocolate brown.

Color terms are unit modifiers in "olive-green shale" and "brick-red clay."

Rules for use of hyphens in rock names, with examples, are given on page 167.

The GPO style manual rules for compounding differ somewhat from WNI 3 recommendations. The manual contains a preferred-usage list of thousands of compound words; Survey authors should check their manuscripts against GPO usage for words given in this list.

Capitalization

1. Capitalize prepositions or prepositional phrases, such as "d'," "da," "de," "di," "du," "de la," "della," "van," and "von," in personal

names used without the forename, a professional title, or a title of nobility or of courtesy.

Della Crusca	Da Ponte
Van't Hoff	Di Stefano
Von Humboldt	De Verneuil

Lowercase such prepositions if they follow the forename, a professional title, or a title of nobility or of courtesy.

G. dell'Acqua	Alcide d'Orbigny
Captain de Cesnola	G. dal Piaz
Constantin von Ettingshausen	P. del Pulgar
J. H. van't Hoff	Fischer de Waldheim
L. G. de Koninck	Senhor da Yznaga

In authors' names, follow individual usage, if ascertainable.

van Dyke De Koven d'Orbigny

2. In text, capitalize the first word and all important words of the titles of books, articles, and reports. Enclose the titles in quotation marks, as "Refractory Clay Deposits of South-Central Colorado."

3. Do not capitalize derivatives of proper names no longer identified with the names from which they were derived.

babbitt metal	nicol prism, crossed nicols
canada balsam	pitot tube
carlsbad twins	plaster of paris
china clay	portland cement
diesel engine	roman type
harveyized steel	taintor gate
india ink	venturi tube

4. Do not capitalize a common noun used with a date, number, or letter only to denote time or sequence or only for the purpose of reference, record, or temporary convenience. "No." or "number" is not used before a figure unless needed:

Well 3 (*not* well No. 3) is 85 feet deep.
Of all the analyses, No. 3 (*or* that of water from well 3) shows the highest fluoride content.

analysis 15	exhibit A	section 10
appendix A	figure 7	species 2
bed 4	level 2	table 19
chapter 3	page 245	test hole 4
class I	plate 23	type F
collection 6812	sample 156	well 162

5. Capitalize the name of a biological phylum, class, order, family, or genus; do not capitalize the name of a species, subspecies, or variety.

Arthropoda	*Agnostus*
Crustacea	*Agnostus canadensis*
Foraminifera	*Diplotrypa westoni*
Hypoparia	*Epigaea repens*
Agnostidae	*Quercus palustris*

Do not capitalize coined paleontological terms derived from proper names.

aviculoid mesodontine foraminifer

6. Capitalize "department" if the word is part of a name; capitalize it standing alone if it refers to a Federal or international unit.

Department of the Interior; the Department

Yale University Department of Economics; the department

7. Capitalize the full names of organized bodies and the distinguishing substitutes for such names.

Connecticut Geological and Natural History Survey
Fortieth Parallel Survey
Geologic Names Committee
Hayden Survey
Idaho Bureau of Mines and Geology
National Center
North Carolina Geological Survey
Office of the Director
U.S. Geological Survey; the Survey
Water Resources Division

8. Capitalize both formal and popular names of bodies of the cosmos, including Sun, Moon, and Earth, when the name refers to the entity: Andromeda Nebula, Big Dipper, Haley's Comet, Jupiter, Milky Way, Morning Star, Phoebe (a moon of Saturn), Polaris; *but* earth-moving equipment, moon rocks, "The stars at night * * *."

9. Capitalize "state," "province," and "commonwealth" when the words refer to national political subdivisions.

State of Maine; the State
Province of Ontario; the Province
Maritime Provinces (of Canada); the Provinces
Commonwealth of Pennsylvania

Parallel Construction

Sentence elements that are parallel and equal in logic should be parallel and equal in grammatical and stylistic form.

1. Coordinate conjunctions ("and," "but," "or," sometimes "for," "nor," "yet") usually signal the need for parallel construction. A shift in verb tense, voice, or mood after a coordinate conjunction violates the principle of parallelism and may also create other difficulties:

Only 20 percent of the water is left for possible water-supply use and to maintain streamflow and ground-water levels.

Only 20 percent of the water is left for possible water-supply use and for maintenance of streamflow and ground-water levels.

Tours of the facility will begin following the ceremony on Friday and continuing through Saturday.

Tours of the facility will begin on Friday following the ceremony and will continue through Saturday.

Limestone in massive layers and thin beds of shaly sandstone * * *.

Limestone in massive layers and shaly sandstone in thin beds * * *.

2. Correlative conjunctions ("both * * * and"; "either * * * or"; "if * * * then"; "neither * * * nor"; "not only * * * but also") require parallel grammatical forms: If a verb follows one, a verb should follow the other; if a prepositional phrase follows one, a prepositional phrase should follow the other. Repair of faulty parallelism may require only transposition or addition of a word or two.

To the northeast, the sandstone bed both became thicker and coarser grained.	To the northeast, the sandstone bed became both thicker and coarser grained.
Either the water was too turbulent or too shallow for such bottom-dwelling species.	The water was either too turbulent or too shallow for such bottom-dwelling species.
The program not only aimed at development of techniques that would be useful in the present emergency but also would improve the efficiency of normal operations.	The program aimed at development of techniques that not only would be useful in the present emergency but also would improve the efficiency of normal operations.
Either the Director or Associate Director must authorize the project.	Either the Director or the Associate Director must authorize the project.

3. "And which," "and who," "and that," "but which," "but who," or "but that" needs a preceding "which," "who," or "that."

This district, the largest and which contains the principal mine, is in the western part of the county.	This district, which is the largest and which contains the principal mine, is in the western part of the county.

For "The district that is the largest and which contains the principal mine * * *," write either "The district that * * * and that * * *" or "The district which * * * and which * * *."

4. Items in a list, in a reading column of a table, and in the description of a process should be in parallel format:

a. Assemble laboratory equipment.
b. Arrange samples in proper sequence.
c. Run tests.
d. Record results.

Not:

a. Laboratory equipment should be assembled.
b. Then arrange samples in proper sequence.
c. Tests are run.
d. We recommend that results then be recorded.

5. Items in a series need parallel construction.

The content of CRIB is based on user response, individual discussions, and by certain requirements of the GYPSY program.

The content of CRIB is based on user response, individual discussions, and certain requirements of the GYPSY program. *Or*: * * * on user response, on individual discussions, and on certain requirements of the GYPSY program.

The Department of the Interior has 15 Skylab experiments in which their scientists are principal investigators, co-investigators on four other experiments, including one experiment with the Italian Geological Survey.

Scientists of the Department of the Interior are principal investigators on 15 Skylab experiments and are co-investigators on four other experiments, including one with the Italian Geological Survey.

6. Expressions of comparison and contrast need parallel construction:

The instruments on Skylab are more complex than the ERTS payload.

The instruments on Skylab are more complex than those on ERTS.

Words, phrases, and clauses in apposition need at least similarity of vocabulary, structure, or logic, if not exact parallelism.

Dr. Smith said that Skylab marks an additional chapter in the use of technology to study the earth's resources—an era that made great progress with the launch of the first Earth Resources Technology Satellite.

Dr. Smith said that Skylab marks an additional milestone of progress in the use of technology to study the earth's resources—a study that made great progress with the launching of the first Earth Resources Technology Satellite.

Also contributed by the Survey, and focusing attention on how the Federal government responds to environmental problems, is an active-fault recorder.

The Survey also contributed an active-fault recorder; the presence of this instrument focuses attention on how * * *.

A change of prepositions in what should be parallel phrases may be awkward or confusing:

It provides the Geological Survey with a means of organizing mineral-resources information and for presenting the results * * *.

It provides the Geological Survey with a means of organizing mineral-resources information and of presenting the results * * *.

It should be noted, however, that if the clauses of a sentence are not equal in logic, that is, if one clause is a consequence of or is otherwise dependent on the other, a coordinate conjunction is not appropriate.

The field-party chief became disabled, and the expedition was canceled.

When the field-party chief became disabled, the expedition was canceled. *Or*: The expedition was canceled because the field-party chief became disabled. *Or*: The field-party chief became disabled, and so the expedition was canceled.

But even parallel construction, if it can be achieved, may not be enough to redeem a sentence that tries to cram too much in too little:

> The unique combination of geologic events, beginning with a vast series of lava flows, then regional tilting of the land, followed by deposition of a one-hundred- to two-hundred-foot layer of windblown silt, and ending with a glacial lake dammed and suddenly released to form the earth's greatest known flood, involved such a large area that only parts of the picture can be seen at one time.

The writer seems to mean:

> The unique combination of geologic events began with a series of vast lava flows, continued through regional tilting of the land and deposition of a one-hundred- to two-hundred-foot layer of windblown silt, and ended when a glacial lake was suddenly released to form the earth's greatest known flood. These events involved such a large area that only parts of the picture can be seen at one time.

Suggestions as to Expression

The English language is a rich and flexible tool of communication. Its vocabulary is perhaps four times as large as that of any other language, but this vocabulary does have a great deal of imprecision, partly because English is a living, growing language and word meanings change. Not long ago "model" meant a curvaceous damsel, or it might mean a toy train; now it may mean an intellectual concept, presented for the sake of argument though not necessarily with conviction. "Discipline" had military or parental connotations; now it may add a comforting aura of intellectual respectability to some large or small segment of the spectrum of science. A few years ago writers made a distinction in meaning between "verbal" and "oral"; now, though "oral" may still be more explicit than "verbal," many educated readers would regard any attempt to distinguish the two words as semantic quibbling. Not only do word meanings change; possible meaning of a given word may range from slightly different to exactly opposite: Does "I fight with him" mean "for him" or "against him"?

The comments and suggestions as to expression that follow are limited to a few words and phrases that have occurred in Survey publications. Many and more voluminous and exhaustive works on word usage are available. Skillin, Gay, and others (1974, p. 406–469) have particularly useful comments and examples pertaining to "Wordiness," "Trite Expressions," "Appropriateness," "The Right Preposition," and "Words Likely to be Misused or Confused."

These comments as to expression concern established common terms. If the writer is introducing a new technical term or if he is defining a term for use in his paper only, he can say with Humpty-Dumpty, "* * * it means just what I choose it to mean * * *." Otherwise, Alex-

ander Pope's advice to "Be not the first by whom the new are tried, nor yet the last to lay the old aside" is particularly appropriate in the matter of vocabulary; it is well to avoid both the esoteric and the trite.

"A, an"

"An honor, an hour," but "a historical event" are correct usage. In current American usage, only "heir," "honor," "hour," and derivatives begin with silent "h's."

"Accuracy, precision"

"Accuracy" and "precision" are not synonymous. A measurement, or a memory, can be precise but quite inaccurate. "Precision" has to do with the fineness of a given value; that is, "2.462 m" is more precise, but not necessarily more accurate, than "2.4 m." In the terminology of statistics, "accuracy" is the agreement of a measured or computed value with the absolute or true value; "precision" is the degree of coincidence of repeated measurements of a single quantity.

"Also"

"Also" is best reserved either for adverbial use ("The trail was also very steep.") or for the phrase "and also." "Also" should not begin a sentence or an independent clause.

The trail was rocky; also it was very steep.	The trail was rocky; it was also very steep. *Or* (better): The trail was steep and rocky.

"Altitude, elevation"

Both "altitude" and "elevation" are used in referring to distance above sea level, but "elevation" also means uplift and is used in that sense in many geologic reports, as "* * * elevation of the two areas to their present altitudes." "Altitude" is preferable for indicating distance above sea level or other datum. However, "elevation" is a well-established term in industry and among topographers and engineers, and their use of "elevation" for "altitude" is followed appropriately in many Survey reports. The terms should not be used interchangeably in the same report. If "elevation" is used for indicating distance above or below sea level, it should not be used in the same report for indicating uplift.

"And (or)"

The legalistic "and (or)" can usually be avoided. "Or" or "and" alone may make the meaning clear; "or both" may be added.

In some places the succession of shale beds is interrupted by lenses of sand and gravel.
The sequence may include limestone or sandstone or both.

"As, since"

"As" or "since" to mean "because" may be confusing, particularly at the beginning of a sentence; "since" is better reserved to express time. However, "since" is conventionally used instead of "because" in mathematical development:

Since	a=b,
and since	b=c,
then	a=c.

"As follows"

Before using "as follows," consider whether the phrase is really needed. A runyonesque aura clings to the phrase, and it is usually superfluous.

"Based on, on the basis of"

The "based" of "based on" is a past participle; it must either modify a noun or a pronoun or it must complete a verb phrase. "On the basis of" is an adverbial phrase.

Based on measurements made on photographs, Brown estimates * * *.	On the basis of measurements made on photographs, Brown estimates * * *. *Or*: Measurements based on photographs enabled Brown to * * *.
The selection of the landing site was on the basis of sound scientific reasoning.	The selection of the landing site was based on sound scientific reasoning.
The relative ages of some of these lava flows could be mapped on satellite imagery, based on the different states of lichen colonization of the flows.	The relative ages of some of these lava flows could be mapped on satellite imagery on the basis of the different states of lichen colonization of the flows.
About 40 percent of Mercury has been mapped based on Mariner 10 data.	About 40 percent of Mercury has been mapped on the basis of Mariner 10 data.

Placement in the sentence of "on the basis of" needs care:

The rocks on the basis of size of grain may be divided into sandstones and conglomerates.	The rocks may be divided into sandstones and conglomerates on the basis of size of grain.

"Both, different"

"Both" and "different" are useful words if needed, but be sure they're needed; they are not needed in these sentences:

Both branch chief and project leader will depart in opposite directions.
The Survey occupies more than 30 different buildings.
Bill Macy has married Samantha Harper, and they both are honeymooning in Hawaii.

"Comparatively, relatively"

"Comparatively" and "relatively" have come to mean "rather" or "a small amount," but the words are more informative if a comparison or a relation is shown. Compared to what? Relative to what?

Conjunctions for emphasis

Coordinating conjunctions ("and," "but," "nor," "or," "yet") may begin a sentence, particularly in informal writing or if emphasis is needed.

> We began the journey in mid-August. And we were very glad when it was over.

But subordinating conjunctions may not properly begin a simple or a compound sentence.

We began the journey in mid-August. So we arrived in mid-September, and then we returned late in October.

We began the journey in mid-August, arrived in mid-September, and returned in late October. *Or*: Because we did not begin the journey until mid-August, we did not arrive until mid-September; then we returned in late October.

"Contour, contour line"

In text, a distinction should be made between "contour" as applied to the surface of the earth and "contour line" as applied to a topographic map.

> The greater resistance of the Paleozoic rocks is indicated by the contour (*or* contours) of the hills.
>
> On the map the 1,000-meter contour line is near the shore of the lake.

General usage among engineers allows use of "contour" instead of "contour line" if a specific contour is mentioned.

In a map explanation, where there is no possibility of misunderstanding, "contour" may stand for "contour line," as in the explanation beneath the symbol for a contour line: "Contours drawn on top of Precambrian rocks; interval, 200 meters" (omit final period on maps).

Numerals indicating altitude (or elevation) on contour maps, and similar numerals on other illustrations, by convention are printed without a comma if they are of four digits, with a comma if they are of five digits or more; in text, however, numerals of four digits or more indicating altitude are printed with a comma.

"Develop"

"Develop" and its derivatives have special meanings in the mining, real estate, biological, photographic, political, and other fields. To "develop" an ore body is to do the work necessary to show its extent; to "develop" a mining property is to do the work necessary to open up the ore bodies. The work done for these purposes is "development" or

"development work." "Develop" has a particular meaning also in water-well construction. To "develop" a well is to remove, by any of several means, fine-grained material adjacent to the drill hole to enable the water to enter more freely. "Develop" is also used in referring to the exploitation of ground water.

Writers of Survey reports would do well to limit use of "develop" to such as:

It is the only deposit that has been developed.
The deposit will soon be developed.
The company began to develop the mine.
Large supplies of ground water are developed in this area.
The ground-water development in this area is intensive.

Some undesirable uses of "develop" are shown below.

Here the vein is developed in greater thickness.	Here the vein ts thicker.
Barren gossans developed at depth yielded rich deposits.	Barren gossans were underlain by rich deposits.
At the crest of the hill the conglomerates are typically developed.	At the crest of the hill the conglomerates are exposed in typical form. *Or*: At the crest of the hill the conglomerates are exposed in typical character and thickness.

"Due to, owing to"

The Survey long maintained that "due to" is adjectival and that "owing to" is adverbial (STA 5, p. 158), but a large body of current semantic opinion concedes adverbial capabilities to "due to"; most language authorities would object neither to "The rivers rose due to exceptional rainfall" nor to "The rivers rose owing to exceptional rainfall." WNI 3 defines both the phrases as prepositions. Other semanticists refer to such phrases as "double prepositions," "compound prepositions," "phrasal prepositions," or "group prepositions." ("By means of," "according to" are perhaps more common examples of "group prepositions.") "Because," "because of," or "caused by" can usually be substituted for either "due to" or "owing to." "Because" is preferable to "owing to the fact that" or "due to the fact that." "Owing to" should not be used after the verb "to be": "Damage was due *(not* owing) to the earthquake," or "Damage was caused by the earthquake": that is, "due to" may be adverbial but "owing to" may not be adjectival.

Expressions of indefinite time and place

The meticulous writer will reserve adverbial words and phrases such as "at times," "often," "sometimes," "when," and "while" for expressions of time. Adequate expressions for denoting place are usually available.

These phenocrysts are often deeply corroded.	Many of these phenocrysts are deeply corroded.

The complexity of the folding is sometimes very marked.	The complexity of the folding is very marked at some places.
These terraces are frequently covered with gravel.	Many of these terraces are covered with gravel.
These pebbles almost never have striated faces.	Few of these pebbles have striated faces.
These pebbles are usually light gray, although some are light yellow.	Most of these pebbles are light gray, although some are light yellow.
The ore was richest when it was most altered.	The ore was richest where it was most altered.

Survey publications, we hope, are for the ages, so expressions like "recent," "last year," "next year," and "6 months ago" should be rigorously avoided. Write, rather, "in 1968," "in December 1974," or "on Dec. 8, 1972," as applicable.

"Fish" or "fishes"?

WNI 2 says that "fishes" signifies "diversity in kind or species," otherwise the plural of "fish" is "fish." "Antelope," "bison," "deer," "elk," and "moose" are either singular or plural.

"Former, latter"

Any incipient inclination to use "former" and "latter" probably should be resisted. Wood, in STA 4 (1935, p. 69) quotes William Dean Howells in "Harpers Magazine" (March 1914) on the subject:

> Why any human being should write "the former" and "the latter" when all are at liberty to repeat with distinction the nouns that these pronominal stuffed images stand for we never could comprehend.

If "former" and "latter" are used, make sure their references are present and clearly identifiable.

"Fortunately, unfortunately"

"Fortunately" and "unfortunately" are expressions of opinions that probably are not subject to scientific analysis; the words are usually superfluous.

"Good, bad; well, poor"

Instead of using indefinite, abstract descriptive terms such as "good," "bad," "well," and "poor," try to be specific.

A well-exposed body of typical granodiorite * * *	A 30-ft exposure of typical granodiorite * * *.
The best site on the planet for finding "fossil" water * * *	The most likely site on the planet for finding "fossil" water * * *

"Horizon"

"Horizon" is sometimes improperly used for "bed" or "stream" as in the sentence "This horizon is 4 feet thick." The term "horizon" denotes

position. Strictly speaking, horizon has no thickness, being merely a stratigraphic level, or plane.

Several thin horizons are resistant and stand out prominently.

The total thickness of the horizon that carries the conglomerate is 20 feet.

Several thin beds are resistant and stand out prominently.

The total thickness of the conglomeratic beds is 20 feet.

However, when applied to soil, "horizon" is properly used for a zone having thickness. By virtue of universal usage, the "A horizon," "B horizon," and other "horizon" terms of soils refer to definite zones. Too, "oil-bearing horizons" and "fossil-bearing horizons"—which obviously refer to units having thickness, else they could not contain the oil and fossils—are used by many oil geologists and stratigraphers.

"Important"

As a rule, "important" is not the appropriate word unless it is accompanied by some term showing why or how the thing described is important, as "commercially important." It should not be used for "large," "abundant," "conspicuous," "valuable," or other words of well-understood meaning. For clear thinking as well as clear writing, a writer should fortify "important" by pointing out the relation that endows the indicated phenomenon with importance. When that has been done, the need for the adjective often disappears.

The most important route across the region * * *.

The most important igneous rock in this area * * *.

These streams, named in the order of their importance, are * * *.

Tne most heavily traveled route across the region * * *.

The most abundant igneous rock in this area * * *.

These streams, named in the order of their commercial importance (size? accessibility?) are * * *.

"Include, comprise, constitute, consist of"

"Include" indicates that the components listed do not constitute the whole; "comprise," "constitute," or "consist of" indicates that they do.

Typical granite is composed of (consists of, comprises) feldspar, quartz, and dark accessory minerals.

Feldspar, quartz, and dark accessory minerals constitute the typical granite; *but* Typical granite may include fragments of country rock.

"It is apparent, it is interesting"

If "it is apparent, clear, evident, or obvious that * * *," then it may not need to be said at all. The phrase is somewhat patronizing.

"It is interesting * * *" may express the author's hope rather than a documented fact.

If it is "needless to say," then don't say it. There is enough to say that needs to be said.

"Lend, loan"

Neither WNI 2 nor WNI 3 offers any objection to use of "loan" as a verb, but the American Heritage Dictionary indicates that such usage seems somewhat uncouth to some of its advisers, that "lend" is preferable; the Oxford English Dictionary observes primly that "loan" as a verb is "chiefly U.S." usage.

"Lie, lay; overlie, underlie"

The parts of the intransitive verb "lie" are: lie, lying, lay, lain ("He lay on the bed"). The parts of the transitive verb "lay" are: lay, laying, laid, laid ("He laid the object on the table"). "Water-laid sediments" are sediments that were laid down (deposited) by water; the "laid" is transitive.

Dictionaries define "overlie" and "underlie" as transitive verbs, but the parts of these verbs are those of the intransitive "lie"; that is, "Something lies over or under something," the "lies" being, in effect, intransitive and the "over or under something" an adverbial prepositional phrase:

> The upper beds overlie the lower beds.
> The upper beds are underlain by the lower beds.

"Like"

"Like" is a useful but troublesome word. Otherwise respectable writers from Shakespeare on have used it as a conjunction, but such usage is still frowned on by intellectuals. "* * *, as a cigarette should" may not be as catchy, but it's better grammar.

Literal versus figurative

The language is full of words and phrases whose idiomatic or figurative usage is in no sense incorrect but for which more literal terms are usually more appropriate in a technical report. A few such are listed; there are many others.

Figurative	*Literal*
a number of	several, a few
accountable for	the cause of
essentially	principally, mostly
evidenced	showed, indicated
grows	becomes
improve	increase
in case of	if
in the vicinity of, in the neighborhood of	about, nearly
majority	most
open; close	begin, end
over; under	more than; less than
proposition	undertaking, task, prospect, matter
provided, provided that	if
ranges up to	is as much as
various	many, several

"May, might; can, could"

Etymologically, "might" in all its uses and meanings is the past tense of "may," but in expressions of probability the distinction between the two words is tenuous. "Might" has perhaps a slightly more negative connotation than "may": "May" implies the somewhat dubious possibility that such and such will happen or (with "have") has happened; "might" usually implies that such and such probably did not or will not happen. However, the two words are almost interchangeable in usage to express probability:

He might go.
He may go.
If he had known, he might have gone.
If he had known, he may have gone.

"Can" and "could" currently seem to denote literal possibility rather than any degree of probability.

A prohibition

One of the few unequivocal prohibitions we issue to Survey writers is: Avoid the round-circle syndrome; it is a nearly infallible sign of linguistic ineptitude.

advance planning, preparation
bisect into two parts
completely absent, obliterated
downward, upward direction
first initiate
green, black, red in color
join together (religious ritual always excepted)
metric unit of measure
originally of * * * origin
refer back
relative proportion, percent ("percent" is relative; it means "per hundred")
repeated repetition
rise up, sink down
surrounded on all sides
throughout the whole, the entire

Skillin, Gay, and others (1974, p. 407–410) list many more similarly objectionable phrases.

The square-circle syndrome ("inaudible sound," "uniquely numerous," "partly saturate," "doubtful certainty," "immaterial matter") occurs so infrequently in Survey manuscripts as to warrant omission of discussion.

"Number"

"Number" or its abbreviation is usually not needed in identifying an item in a numerical or alphabetical sequence:

chapter 3
class I
collection 6812
exhibit A
figure 7
section 10
table 19
well 162

"On the order of"

"On the order of" should be used only in connection with an established order of magnitude, velocity, intensity, or other; it should not be used to mean "approximately" or "about."

A great earthquake in the densely populated areas of the Pacific coast could cause property damage on the order of tens of billions of dollars.

A great earthquake * * * property damage of tens of billions of dollars.

"Order of magnitude"

An "order of magnitude" refers to some value that is 10 times more than the preceding order or 10 times less than the succeeding order. "Several orders of magnitude" should not be used carelessly to say that one quantity is many, many times larger or smaller than another. "Two quantities are of the same 'order of magnitude' if one is no larger than ten times the other, but if one is one hundred times the other it is larger by two orders of magnitude" (WNI 3).

"Percent, percentage (proportion)"

Previous Survey usage (STA 5, p. 205) and the American Heritage Dictionary forbid use of "percent" except with a numeral, as "4 percent copper," which means "4 parts of copper per hundred parts of rock." By these usages "a large percent" is incorrect; the correct phrase would be "a large percentage." WNI 2 and WNI 3 have no objection to "a large percent"; both list the phrase in examples of usage. Evans and Evans (1957, p. 363) wash their hands of the matter: "* * * anyone who likes to make distinctions can do so." The Chicago style manual (p. 278) considers use of "percent" as a noun to be colloquial.

"Percentage" is synonymous with "proportion"; it should not be used when no proportion is being expressed:

> The greater part (*not* greater percentage) of the soil of the area is of glacial origin.

"Percent" is preferred to "percentage" for table headings. If other terms, such as "meters" and "centimeters," are abbreviated in a table, "percent" may be abbreviated as "pct." It is not abbreviated in text. The symbol "%" is not used.

Prepositional idioms

The current usages of a few common prepositional idioms are given below. Funk and Wagnalls' "Standard Handbook of Prepositions, Conjunctions, Relative Pronouns, and Adverbs" (1953) contains exhaustive lists and much pertinent information on English connectives.

compare: one thing **with** another, similar thing; one thing to another, different thing
conform: **to** practice, **to** a design; comformable **to**, in conformity **with**
consist: **in** performing an act, or **in** a definition or statement of identity; **of** quartz and calcite
contrast (verb): one thing **with** another
contrast (noun): **between** things; present a contrast **to** a person or thing; one person or thing placed in contrast **with** another
correspond: correspond **to** things, correspond **with** (write letters **to**) persons
differ: pyrite differs **from** gold; he differs **with** that opinion

different from (*not* different **than**)
essential: essentials **of** geology; essential **to** success; the first essential **in** preparing a specimen
identical: one thing **with** another (not **to** another)
in search **of**; the search **for**
independent **of** (*not* **from**)
necessary: **for** a trip; **to** advancement
overlain **by** (*not* **with**).

"Provided, providing; if"

WNI 2 and 3 seem to consider "provided" and "providing" equally acceptable when used as conjunctions; American Heritage prefers "provided." "If" is shorter and can always be used rather than either.

"Render"

"Render" is unquestionably respectable in any of its various meanings, but it is becoming archaic, and the Survey writer is urged to leave it to judges, to Holy Scripture, and to lard-makers.

"Section, area, region"

"Section" is a word of many possible meanings. In geologic reports, "section" may be reserved with advantage to designate a land section, vertical section, cross section, or thin section, and perhaps for a few other uses; "place," "locality," "area," "quadrangle," "district," or "region" may serve as geographic terms. If a distinction is needed, use "region" for the larger unit and "area" for the smaller. Consistency of usage should be maintained; the "region" of one sentence should not become the "area" or the "district" of the next sentence.

Simliar words, easily confused

The language has many words similar enough in form but different enough in meaning to require care in use. A few are listed:

affect, effect
all together, altogether
altar, alter
appraise, apprise
bough, bow
conscientous, conscious
continuing, continuous
data, datums
flair, flare
fortuitous, fortunate
ingenious, ingenuous
staid, stayed
tortuous, torturous
valance, valence

"So that, such that"

Use of "so that" and "such that" to express result can produce awkward sentences. "And so" may be a better choice than "so that," and sentence rearrangement will smooth out the awkwardness of "such that."

The average rate of occurrence of great earthquakes along the San Andreas fault is about once every hundred years. The last such event was 70 years ago, so that a significant probability exists of another within the next 30 years.

The average rate of occurrence * * *. The last such event * * *, and so a significant probability * * *.

The capillary is observed end-on in a direction such the light rays used travel from the cathode end to the anode end.

The capillary is observed end-on in such a direction that * * *.

The relative pronouns "that" and "which"

It would be convenient to be able to say confidently that the relative pronoun "that" introduces a restrictive clause and "which" introduces a nonrestrictive clause, but English usage is not so neat and orderly. The truth is that "which" and "that" appear almost interchangeably even in the most respectable usage, though some writers and some editors do insist on "which" for nonrestrictive clauses. (Restrictive: "Measurements that are inaccurate are worthless." Nonrestrictive: "The measurements, which were made by Jones, are inaccurate.") But if two relative clauses modify a substantive, parallelism applies: "The * * * that * * * and that * * *" or "The * * * which * * * and which * * *."

"There is * * *"

Such phrases as "There is," "There were," "There have been," "It is," "It was" may, of course, properly and preferably begin many sentences, but the writer who is about to use one of these phrases should consider whether he cannot express his thought more forcefully in some other way.

There are many other primary minerals containing phosphorus.

Many other primary minerals contain phosphorus.

There are some places where lignite beds are exposed.

At some places lignite beds are exposed.

There has been some faulting subsequent to the deposition of the ore.

Some of the faulting occurred after the deposition of the ore.

It is believed that these vugs probably represent openings which were formed by recent faulting.

These vugs probably represent openings formed by recent faulting.

It is the belief of the miners that the ground now being worked may be a slide.

The miners believe that the ground now being worked may be a slide.

There is a probability that some of the veins may have had their gold content increased by enrichment.

The gold content of some of the veins probably was increased by enrichment.

"There is no doubt * * *"

"There is no doubt," "undoubtedly," "unquestionably," "certainly," and like words and phrases usually weaken otherwise firm statements.

There is no question but that * * *. [A very broad and all-inclusive statement]
It can be readily seen that * * * [Where? By whom? And are you certain?]

"* * * to end a sentence with"

The strict grammarian's objection to "using a preposition to end a sentence (or a clause or a phrase) with" is that a preposition by definition is a connective placed before ("pre-positioned") another word, that is, its object; if the preposition has no object, it is hardly a true preposition. Most sentences, clauses, or phrases can easily be recast to avoid need for such usage: "The strict grammarian's objection to ending a sentence with a preposition * * *."

Note that any objection to ending a sentence with a preposition applies equally to ending a clause or a phrase with a preposition. Note also that some words may quite properly be used as either prepositions or adverbs:

The fog crept in. (adverb)
He spoke in the vernacular. (preposition)
We saw that before. (adverb)
We stood before the house. (preposition)
They hauled the flag down. (adverb)
They ran down the hill. (preposition)

There are others: "Inside," "off," "on," "out," "over," "past," "under," and "up" may all be used as either prepositions or adverbs; some may even be used as adjectives, nouns, or verbs, particularly in colloquial or informal speech.

"Toward, towards"

Most dictionaries accept either "toward" or "towards," but GPO style manual prefers "toward." "Towards" is usual British usage.

Trite or superfluous phrases

Skillin, Gay, and others (1974, p. 410–415) list several hundred phrases that may once have been new or needed but now are either worn out through overuse or else were never needed. Below are a few that have been noted in Survey manuscript, together with suggested revisions.

along these lines	Omit.
due to (or because of) the fact that	because
in many instances	at many places, frequently, often (depending on meaning)
in (the) case of	if (if applicable; otherwise probably superfluous)
it has been found, is a known fact that	Omit.
of distinctive character	distinctive
present, presence	Usually not needed.

situated, located	Often superfluous.
took some of their valuable time	took time, *or*, better, "did such and such"
was engaged in studies of	studied
was (or were) found, known, seen to be	Usually the single word "was" or "were" is adequate.

Twins and triplets

The English vocabulary has many twin or triplet words that are of similar meaning but of different form because they come from roots in different languages or from different roots in the same language. In most of these pairs or groups, the shorter, more common form is from Anglo-Saxon, the longer, more formal from Latin or Old French:

about; approximately
clayey; argillaceous
find; locate
inside; interior
many; numerous
outside; exterior
part, portion (both Latin)
sandy; arenaceous
show; exhibit
start, begin; initiate
stop, end; terminate
talk; converse
And many others.

These words may have fine distinctions of connotation to different minds, but such distinction is usually not worth editorial-authorial quibbling—author and editor bearing in mind that simplicity of vocabulary and sentence structure more than any other factor equals intelligibility.

"Two or three"

Phrases such as "two or three," "eight or ten," and "two or three hundred" occur routinely in conversation and in informal writing, but the scientific writer may want to consider whether he means "two to three," "eight to ten," or "two to three hundred."

"Unique"

"Unique" is generally considered to be not comparable, either positively or negatively. Rather than "more unique," try "more rare"; rather than "less unique," try "more abundant," or some appropriate variation. Some language authorities frown on comparing "fatal," "round," "permanent," "stable," and other terms of specific and limited meaning.

"Very, merely, simply"

"When you write 'very' in a news story, scratch it out and substitute the word 'damn.' Then scratch out the 'damn,' " William Allen White advised a young reporter. Young geology authors, and older ones too, take note. "Very" can be made informative in spoken English by voice manipulation, but it usually adds little to a written statement. Repe-

titious use of the written "very" (or any other general term) gives a paper an amateurish tone.

"Damn" is not a satisfactory substitute for either "merely" or "simply," but the two words are about as empty of written meaning as "very."

"Whether or not"

When the alternative is the negation of the possibility expressed by the correlatives "whether" and "or," the "or not" may immediately follow the "whether" or may be placed elsewhere:

The condition exists whether or not there is a rational explanation.
The condition exists whether there is a rational explanation or not.

The "or not" may even be omitted:

I would like to know whether there is a rational explanation.

"While"

It is well to avoid beginning a sentence with "while." The word has been so misused the reader cannot immediately tell whether the meaning is "during the time" or "though." See also "Expressions of Indefinite Time and Place" (p. 243).

"With"

Ever since George McLane Wood wrote STA 1 in 1909, Survey authors have been admonished not to "misuse" the preposition "with." In STA 1 (p. 42) the caution was stated in four lines. In STA 5 (p. 172), 33 lines were needed to delineate possible misuses. From WNI 2 to WNI 3 the definitions of "with" increased from 11½ to 12½ columnar inches. The struggle against "misuse," or overuse, of "with" seems to be a losing one, but we will repeat Mr. Wood's comments and add a few examples of undesirable usage from STA 5 and other sources.

"With" is much misused, especially for "and." An example of misuse is seen in the sentence "At San Marcial the average rainfall is 4.84 inches, *with a* (and the) minimum *of* (is) 1.17 inches."

The mechanic advised the woman with the broken cylinder head to report it to the company's regional office.	The mechanic advised the woman to report the broken cylinder head to the company's regional office.
The water is very clear with a faint bluish tinge.	The water is very clear but has a faint bluish tinge.
The surface of the bedrock is fairly even with depressions representing temporary channels of the shifting creek.	The surface of the bedrock is fairly even but contains depressions representing temporary channels of the shifting creek.
A fine-grained rock with blotches of a bright pink color * * *.	A fine-grained rock blotched with bright pink * * *.
The conglomerate pebbles are well rounded with a very loose cement.	The conglomerate pebbles are well rounded and loosely cemented.

The top of the mountain is flat with a smooth descent on the south and west.	The mountain is flat topped and has smooth slopes on the south and west.
He discusses the geology of the county with descriptions of 19 mining districts.	He discusses the geology of the county and of 19 mining districts within it.

Authors should be aware that "without" may be as undesirable as "with."

"With regard to"

"With regard to," "regarding," and "in connection with" are acceptable as idiomatic phrases, but other words or phrases may be less awkward: "concerning," "as for," "in respect to," "with reference to," and others. "With regards to," "as regards," "re," and "in re" are better avoided.

Word repetition, desirable and undesirable

If the writer is striving for emphasis, repetition of a key word may produce that emphasis:

> For Brutus is an honorable man;/So are they all, all honorable men.

Parallel construction may require word repetition:

> Young men are fitter for inventing than for judging, fitter for executing than for advising.

But undesirable, usually unintentional, word repetition produces monotony, and sometimes confusion:

> Milky quartz with sparse chlorite and sparse pockets sparsely mineralized with pyrite * * *.
>
> Before assumption of his new post, Smith was assistant program manager for Program Development, Earth Resources Program at the Outer Space Center; the program includes the Earth Resources Aircraft Program and the Skylab Earth Resources Experiment Package.
>
> A dike of agglomerate in the Colorado Prince reverse fault has been faulted by a minor cross fault within the fault zone, due to renewed movement along the main fault.
>
> A number of ice lobes encroached southward onto the lava field and, in doing so, dammed a number of rivers and created several glacial lakes formed when several stream valleys became partly or entirely blocked by dams of glacial debris.

Use of the same word within a sentence to convey different meanings is distracting to the reader, as is the use close to each other of different words of the same root meaning:

> These specimens do not resemble the diatomaceous remains found in the chalky shale, and their character remains indeterminate.
>
> This water contains a higher mineral content.
>
> The nature of natural geologic processes * * *.
>
> Some of the products produced by the Survey from existing satellite photography * * *.

Rapid growth is causing many problems that require basic earth-science knowledge as the basis for wise planning.
The system would include a translation program to produce products applicable to a particular program.
Visitors can review enlarged versions of the space views and learn how such remote sensing is being used.
All are altogether altered.
As the process proceeded, * * *.
He pointed out some points * * *.
A corollary was the rising of the bottoms of the canals, which often rose above the former water surface.

The caution against undesirable word repetition does not apply to technical terminology. Technical terminology must be used consistently throughout a paper. This principle applies even to general terms used with a specialized meaning in a particular manuscript. If, for instance, the author lists in text or identifies on a map "field localities 0–000," he should not interchangeably refer to "sampling site 00," sampling locality 0," "field location 000," or other. A variation in usage of technical terminology raises the question whether a variation in meaning is intended.

It's useful self-discipline for the author to list and define, at an early stage of his writing, the technical terms he intends to use (that is, words or phrases for which a specialized meaning has been or is being established). Whether or not these definitions become part of the completed manuscript, they are useful for reference in maintaining consistency of usage of technical terminology.

Miscellaneous Aids to Clarity

Alliteration

Alliteration (a succession of similar sounds, usually, but not always, initial consonants) may be useful or it may be distracting. Skillfully (but sparingly) used, it is an effective tool for emphasis:

And the rockets' red glare, the bombs bursting in air * * *.
Human life is a state much to be endured and little to be enjoyed.
Never * * * was so much owed by so many to so few.
From Topeka to Timbuktu, from Paris to Pago-Pago * * *.

But thoughtlessly used, alliteration can detract from the dignity of a presentation:

Crustal movements crushed and crumpled the Cambrian rocks.
A somewhat similar series of sediments * * *.
Around these mountains lie low-lying lands.

Intentional alliteration is generally more suitable to literary than to scientific exposition.

"As described above, will be discussed later"

When the reader must be told that something has already been stated or will be discussed in an ensuing section, tell him where, as "This aspect of the problem is discussed in the section on 'Floods of 1970' " *or* " (see p. ___.) ." The page-number cross reference is more convenient for the reader, but obtaining the correct printed-page number sometimes makes for proofing problems. Leave it to the editor to decide whether to give the reader the page number. However, it will be helpful to the editor if the author gives the manuscript-page number of all cross references, and it may be helpful to the author himself in checking revisions of earlier versions of his manuscript.

Consistent use of singular and plural

Consistency should be maintained in the usage of the singular or plural noun form in referring to the same item (s) . "Limestone" in one sentence should not be "limestones" in the next when the reference is to the same material or formation. It is helpful to the reader if the basis of the plural form is made obvious, that is, if he is made aware that the "limestones" refers to samples, beds, formations, compositions, or other.

False economy

Clarity of meaning should not be sacrificed for economy of words: If "defects in logic" is meant, "logical defects" may be ambiguous; if "national program for conserving energy" is meant, "national conservation program" may be misleading.

Make a list

Don't be afraid to list words, phrases, thoughts, or paragraphs by sequential number or letter if such listing clarifies the meaning. The itemization may be either run-in or listed in vertical format. A vertical listing gives emphasis to individual items but may be wasteful of space.

Once should be enough

Sentences and paragraphs beginning with "In other words" or "To put it another way" usually are repetitions of what should need to be said clearly only once: Survey authors are not trying to convince their readers of a "big lie."

Parenthetical relevance

A parenthetical expression should be relevant and material to the rest of the sentence:

> MacIntosh County, which has a population of 40,000 and a rainfall of 40 inches per year, contains outcrops of the formation.

Two, perhaps three, sentences are needed here. It's not always necessary for the scientist to follow the newspaperman's dictum of "one idea, one sentence," but three unrelated ideas in one sentence are at least one and a half too many.

Suffering rocks, and other fallacies

As the author of STA 4 wrote, "What Ruskin calls the 'pathetic fallacy' * * * seems a little far-fetched in a scientific paper," (Wood, 1935, p. 66). It's best to avoid giving animate capabilities to inanimate objects or conditions.

The rocks have suffered deformation.
Similar forms in humid climates suffer basal steepening and may therefore enjoy accelerated back-weathering.
The environment has suffered to a significant extent.
Calcareous algae are a minor element and grow as unhappy small nodular masses here and there.
A weasel was used to scout and lay out the trail.
The published impact statement is divided into seven sections that discuss the subjects listed below.
Barite and intensely silicified rock accompany the ore almost everywhere.
A layer of coarsely crystalline limestone carries bunches of garnet-pyrite rock from place to place.
Remnants of glacial debris stood on the beaches and clung to the cliffs.
The materials underwent fluctuations in pore-water pressure.
The frozen ground argued against lurching and landsliding.

Unintended humor

The careful writer of a technical report will avoid sentences susceptible of unintended facetious interpretation. The entomologist perhaps cannot avoid describing his specimen as having a "well-rounded posterior," but a mineralogist should be able to avoid "The French Girl is more of a prospect than a mine." (Perhaps "The French Girl Mine would more correctly be classified as a prospect.")

This earthquake produced a similar observation by Johnson (1956, p. 31) in marshy ground at the south end of the bay.

This earthquake produced a similar effect in marshy ground at the south end of the bay (Johnson, 1956, p. 31).

See also "Adroit Use of Modifiers" (p. 217).

Where does it end?

When "the following paragraphs" or "the following points" or a similar lead-on is used, the end of the reference should be clearly indicated to the reader and to the editor by use of indentation, sequential numbering of paragraphs, or some other device. If the editor mistakes the end of the passage, resetting of type, always expensive and time consuming, may be required.

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