GOPEN; SWAN (1990)

"In real and important ways, the structure of the prose [is] the structure of the scientific argument. Improving either one will improve the other."

(1) Start a unit of discourse should generally define the topic of discussion. Thus, in a paragraph, the first sentence should usually be the topic sentence; in a sentence, the subject should usually be up front.

(2) The start of a unit of discourse should generally also provide "linkage" and "context" — linkage connecting the topic of discussion to what has come previously, context relating it to what is to come.

(3) The last part of a unit of discourse should generally contain and emphasize the most important observations or arguements.

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A Writing Guide for Petrological (and Other Geological) Manuscripts

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'The journey is one of choices, judgement, of logic—if . . . then . . . and also . . . if not . . . therefore; the small words that have little use alone become instruments of power.'

Janet Frame (1988), *The Carpathians*

ABSTRACT

Many of the manuscripts received by the *Journal of Petrology* are not well written, and the problem is of concern with respect to (a) obtaining prompt, thorough, balanced evaluations of the scientific content, (b) the imposition on reviewers, (c) the time and effort that editors have to spend improving the writing, and (d) the frustrations that the authors themselves undoubtedly experience. The manuscripts are generally long (typically 30–40 pages of typescript plus diagrams), but if they are scientifically acceptable and well written—and if the timing is right for everyone concerned—they can go through the review process in a couple of months. By contrast, poorly written manuscripts stand a large chance of being rejected outright, even though their scientific content may be fundamentally sound and interesting; and if they are accepted, several revisions are sometimes required, a process that can all too easily stretch into a second year. The skill of writing is obviously worth cultivating.

Ideally, a manuscript should embody a smooth, accurate, clear and concise, logical flow of information and ideas, free of ambiguity and with the only repetition being that necessary for emphasis or clarity. The problems associated with preparing manuscripts for publications such as the *Journal of Petrology* divide broadly into two categories. One comprises a multitude of relatively minor points—some grammatical, some relating to the subject, some pertaining to the format of the journal itself. In principle, these problems should not be difficult, at least for authors with English as a first (or strong) language. Awareness and care are the main ways to avoid them. The problems of the other category are difficult. Principal among them are: (1) awkward, wordy, ambiguous, unclear, and inaccurate sentences; (2) lack of coherence and unity, most commonly in paragraphs, but frequently also in larger sections of the text; and (3) repetitious, unfocused, and unnecessarily detailed descriptions and discussions. These problems are essentially matters of logic, and they concern the ability to manipulate words so that observations and thoughts are described clearly and in sensible order, and arguments are developed in reasonable ways. This ability involves verbal techniques and vocabulary that are, for most of us, acquired only through long-term experiences of effective teaching, extensive reading, much practice in writing, and constructive self-criticism.

In this guide, we make recommendations on several dozen matters in the first category. The problems of the second category cannot be resolved by any general recommendations, because their detailed characteristics tend to be idiosyncratic to the author and the subject material. The best overall, short-term solution we can suggest is that authors (especially those with limited experience) try, as much as is practicable, to write their first drafts in the *simplest of sentences*. Then, after the sentences

have been sorted by paragraph and section, and resequenced to eliminate repetition and improve coherence, they can be compounded and subordinated to smooth the writing and focus the presentation. It is much easier and more satisfying to go from an orderly sequence of correct simple sentences to a logical succession of smoothly written compound or complex sentences (formal grammatical terms), than it is to try to unravel, sort, and reformulate lengthy, disjointed sentences and jumbled paragraphs. Important also is to build paragraphs around *topic sentences* using transition terms and key words to maintain continuity of thought.

We emphasize that the writing of a geological manuscript is very much a part of the research process—and not just something to be done afterward—because, not only does it produce the record of the work, it also commonly leads in itself, through the processes of organizing observations and thoughts, to important new observations and insights. The work of writing is essentially a matter of thinking, and the product represents both what and *how well* one thinks, so it is not a job to be treated casually. Our impressions are that many authors are not taking proper advantage of the incredible power of word processors, and that most authors are not getting enough critical review by friends and colleagues—including, we suspect in some cases, nominal co-authors. We appeal to university Earth Science departments to teach more about writing, because current deficiencies in this area are seriously affecting the quality of our science.

INTRODUCTION

This guide is a response to many experiences that we (T.N.I. and D.R.; see Appendix 1 for explanation of authorship) have had with manuscripts over the years, ranging from the problems of writing our own, to difficulties in doing reviews, to our struggles with writing problems during various editing jobs—including, of course, our present ones with the *Journal of Petrology*. The guide is tailored to the *Journal of Petrology* format for obvious reasons, and it has been read by most of the other editors, but it should not be regarded as representing Journal policy. It is essentially a personal compilation of observations and recommendations that we think should make life easier for everyone concerned with petrological papers—particularly authors, reviewers, and editors, but ultimately, even readers.

The guide stems from a three-page list of recommendations on writing that Hatten Yoder prepared when he was Director of the Geophysical Laboratory. He distributed his list annually to the Laboratory scientific staff and fellows to help them in preparing their Year Book articles and other manuscripts. Our original intention was to produce a slightly expanded version that could be sent to *Journal of Petrology* authors together with reviewer comments and our own editorial recommendations. Our thought was that such a document would make our recommendations easier to appreciate and less personal in effect. As we worked on the list, however, its size and scope grew rapidly, and because we were learning a lot ourselves, we soon realized that authors should have it in hand before they write their manuscripts, rather than after. Thus, the list became this guide.

In our research, we frequently consulted the US Geological Survey publication *Suggestions to Authors* (Anonymous, 1958; and Bishop *et al.*, 1978), as well as several books on grammar and technical writing (notably Semmelmeyer & Bolander, 1988; Brusaw *et al.*, 1982; and Reisman, 1962). We did not find the booklet, *Writing in Earth Science* by Bates (1988) until after most of our own text was completed, but we do recommend it. Our treatment overlaps it in some respects and is complementary in others, but we focus more on a particular kind of manuscript, and we give more analysis of the problems that we consider serious.

A brief glossary of grammatical terms is given in Appendix 2. Although not all the terms are used in the text, we strongly recommend that authors review them. Our experience was that relearning their definitions and applications was a surprisingly useful thing to do.

RECOMMENDATIONS ON WRITING PROBLEMS

The writing problems in the manuscripts that we have processed divide broadly into two categories. One comprises a multitude of relatively minor points, some grammatical, some relating to petrologic and other scientific matters, and some pertaining to the format of the journal. Most of these matters are relatively easy to explain, and once aware of them, authors with a reasonable command of English should be able to deal with them. The problems of the other category are much more difficult, because they are fundamentally matters of logic. They involve the ability to describe observations and thoughts clearly and in sensible order, and to develop arguments and interpretations in reasonable ways. They are serious because they are critical to the scientific product, and because they reflect the writer's thinking. As scientists, we describe our work by way of equations, diagrams, and words, but in terms of communication at least, words are unquestionably the most important, because even equations and diagrams require explanation. It seems ironic, therefore, that scientists will almost always claim that their observations, experiments, analyses, and theory can be trusted, yet frequently they seem not to care whether their writing can be trusted.

A further point that might be emphasized here—one that often does not seem to be appreciated—is that the writing process itself is a significant part of the scientific research, and not just something to be done afterward. Important insights and ideas can come, not just while we are making our observations and compiling our data, but also when we are trying to describe them.

In the pages to follow, we comment on problems in 76 titled sections. The sections are grouped under major headings, but they are numbered continuously so that a list of them at the end of the guide can be used as an index. Sections 1–56 are concerned with matters of grammar, word usage, and manuscript organization. The problems are not all minor, but they can be dealt with in relatively straightforward ways. Sections 57–66 discuss the difficult major problems (as we see them); and sections 67–76 explain matters relating to the journal format. Some of our recommendations will probably seem rather stringent, perhaps even old-fashioned, but our contention is that accuracy and freedom from ambiguity are prime considerations, so a certain amount of rigidity is essential. Furthermore, the guide is not intended for accomplished writers; it is primarily for authors whose writing skills are deficient, and for that reason too, certain recommendations are deliberately restricting.

Some matters of grammar and composition

The main, purely grammatical errors that we encounter are dangling participles. An understanding of why they occur involves 'voice' and 'person', and although these are aspects of grammar that most of us rarely consider, they are, nevertheless, remarkably important to the way we express ourselves.

1. Voice

Voice is a matter of verb form:

Active voice: the subject does the action.
The alteration affected the grade of the ore.
Passive voice: the subject is acted upon.
The grade of the ore was affected by the alteration.

Having this option is a powerful feature of our language. As illustrated, it permits one to change the 'grammatical subject' and 'turn the sentence around'. In the case of the above example, the choice of voice would probably depend on the topic of the paragraph. If the

topic was alteration, the active-voice sentence is likely to be preferable; if it was grade of the ore, the passive-voice version might be more appropriate.

The passive voice tends, however, to be flat and uninteresting (boring, if you will), and it commonly leads to awkward, wordy sentences—and dangling participles. It is widely and often intensely disliked, particularly in literature, but geologists use it frequently, and we would presume (or hope) for some valid reason. One of the few circumstances in which the passive voice is acknowledged as being necessary occurs when the 'performer of the action' is unknown. Perhaps, then, its frequent use in geological documents arises because they deal with subject materials (rocks) that were formed (*acted upon*) by the processes and events that are usually the *unknowns* of our research. Certainly, it is impossible for geologists to avoid passive-voice expressions such as 'the rocks were metamorphosed' but most of us also find it difficult to refrain from saying 'the minerals were analyzed' or 'the experiments were run', and that is largely a matter of conditioning. After all, 'we' analyzed or ran them! Try, therefore, to use the active voice as much as possible, particularly to break the monotony in paragraphs in which the verbs read: 'was . . . were . . . was . . . were . . . '. But do not switch voice in mid-sentence:

Poor:[1] The formation consists largely of basalt (active), but some andesite is included (passive).
Better: The formation consists largely of basalt but contains some andesite.

Perhaps the most important point, though, even if you never analyze the voice of your sentences, is: If a sentence seems awkward or out of place, it may be in the wrong voice, so try 'turning it around'.

2. Person

Person is a matter of pronouns:

First Person (singular, plural): I, we
Second Person: you, you
Third Person: he, she, it, they

In this guide, we have used the first and second persons because *we*, as authors, are addressing *you*, as readers (about a matter that is rather personal, *your* writing). However, in the geological manuscripts of concern, only the first and third persons are usually of interest.

Geological writing is largely done in the third person, because the things discussed (rocks and their relationships) are mostly covered by 'they' or by 'it'. But there is also something of a stigma associated with the first person among scientists: their contention is that it is the subject material that is important, not the people describing it. However, increasingly common views (particularly in the rest of the world), are that, in using the third person, scientists are pretending to a position of objectivity and impartiality that is false, and that, in fact, they are trying to avoid responsibility for what they are saying. And all the while, rather ironically, they are actually saying 'This is the way it is' rather than 'This is the way *we think* it is'.

[1] A reviewer objected to our using the words 'good', 'bad', and 'poor', here and at other places. The objection was that the words are indeterminate—i.e., they are imprecise, vague, and lacking in definable reference. (They can also carry moral connotations, although that aspect does not seem relevant here.) We eliminated many occurrences, but not all. The problem was what words to use instead; our language is short on suitable alternatives. We finally concluded, however, that vagueness is exactly what we require, because standards of writing and word usage are so frequently matters of contemporary practice and personal judgement. Indeed, in many dictionaries, a prime example of the use of 'bad' is 'bad grammar'. Thus, let us say that, when we use 'good', 'bad', and 'poor', it is as best we can in terms of what we perceive to be generally accepted standards of grammar and composition among educated English-speaking people. To try to be any more rigorous seems unnecessary for our purposes.

In any case, third-person constructions frequently require the passive voice, hence they often yield awkward sentences and dangling participles. The first person is generally easier to read—and it is much easier to write:

They were examined in June, and no defects were found. (Third person, passive voice.)
I examined them in June and found no defects. (Fewer words, first person, active voice; and in addition, the doer of the action is identified).

We encourage you, therefore, to switch occasionally to the first person, particularly when expressing personal opinions and interpretations.

Use 'I' in single-author manuscripts, 'we' in multi-authored documents.

Be consistent, though: do not use 'I' or 'we' at some places and 'the author(s)' at others. And do not overuse the first person.[2] Too much can be irritating to readers, especially in a discipline where they are not used to it. For multi-authored manuscripts, such excess has been called 'The Fifth Little Pig complex'.

3. Dangling participles

A participle is an *adjective* formed from a verb; *it necessarily modifies a noun or a pronoun.* In present participles, the verb ending is 'ing'; in past participles, it is usually 'ed', less frequently 'en' (as in 'proven').

The volcano erupted, spouting clouds of ash. (Here 'spouting' is a present participle modifying 'volcano'.)

In their modifying relationships, participles are rather like magnets: they always attach to some noun or pronoun. The problem is to be sure that it is the right one.

The flow of lava followed an old stream bed extending 20 km.

Here, the participle 'extending' carries an element of ambiguity that suggests a missing comma (after 'bed'). As it stands, the first of the following interpretations is the more likely grammatically, but the second (which is achieved by adding the comma) seems the more likely geologically:

(1) The flow of lava followed, for an unspecified distance, an old stream bed 20 km long.
(2) The flow of lava extended for 20 km along an old stream bed of unspecified [but presumably irrelevant] greater length.

If participles are not used carefully, moreover, they may modify the wrong nouns in ways that are not sensible—in which case they are said to 'dangle'. This problem mostly occurs with present participles (thus the name dangl*ing*), and the main way to find them is to search out the 'ing' words in your text. Correcting the problem usually requires restructuring of the sentence.

Incorrect: The minerals were analyzed, *using* an electron microprobe. (In this passive-voice sentence, 'using' modifies 'minerals' and the implication is they were analyzed *while they were themselves* using the electron microprobe. In its way, then, this sentence is another example of a writer shedding responsibility!)
Correct: *I* analyzed the minerals, *using* an electron microprobe. (First person, active voice.) But note: *the comma is critical*; without it, the minerals would still be analyzing.)
Better: I analyzed the minerals with an electron microprobe. (First person, active voice.)
Correct: The minerals were analyzed [by me] with an electron microprobe. (Passive voice.)
Correct: An electron microprobe was used [by me] to analyze the minerals. (Passive voice.)

[2] A reviewer complained that, although he agreed with the sentiment expressed here, the recommendation was 'logically impossible to honor'. His point is well taken, but the best we can do in response is use this guide in example. In it, the word 'we' is used, on the average, about two times per *manuscript* page (but it tends to occur in bunches). That is probably a commendable maximum.

The above type of incorrect sentence occurs time and again in geological manuscripts, and it arises because *the authors are (unwittingly) forcing their first-person, active-voice activities into third-person, passive-voice sentences.*

Incorrect: Judging from these data, the magma was intruded in the Late Cretaceous. (In this passive-voice sentence, 'judging' modifies 'magma'—which, of course, is incapable of making judgement.)
Correct: Judging from these data, *we* think the magma was intruded in the Late Cretaceous. (First person, but mixed voice and wordy.)
Correct: From these data, the magma appears to have been intruded in the Late Cretaceous. (Passive voice and wordy.)
Correct: These data imply that the magma was intruded in the Late Cretaceous. (Mixed voice.)
Best?: These data imply Late Cretaceous intrusion of the magma. (Concise, active voice.)

The following dangling participle, also of a common type, is more complicated to explain:

Incorrect: This ash bed is paler pink, indicating a lesser degree of oxidation. (Scientifically, 'paler pink' is the indicator, but in this sentence 'indicating' modifies 'ash bed'—because 'paler pink' is not a noun, it is a predicate adjective attached to 'ash bed' by the linking verb 'is'.[3]
Correct: This ash bed is paler pink, a feature [of the bed] that indicates a lesser degree of oxidation.
Correct: The paler pink of this ash bed indicates a lesser degree of oxidation. (This sentence would require a different structuring of the sentence that preceded it in an actual text.)

Most dangling participles can be avoided by examining each '. . . ing' word in your manuscript and asking the question: What or who is doing the '. . . ing'? If the answer is not rational, then make the necessary correction.

4. Tenses

There are many verb tenses with numerous applications, and we can only make a few general recommendations:

(1) Describe rocks in the present tense:

The sill occupies an unconformity, and its roof rocks are highly altered.

(2) Describe events of geologic history in the past tense:

The magma intruded the unconformity, forming a sill, and shortly after, a hydrothermal system developed in its roof rocks.

(3) Describe experimental activities and phenomena in the past tense; they presumably are completed by the time of writing:

We heated the charge to 1500 °C at 20 kb, and the mineral assemblage partly melted.

(4) Discuss experimental results in both past and present tenses, as appropriate to the conditions and observations:

The experiments show*ed* that the mineral assemblage *is* stable under these conditions.

(5) Describe specific conclusions in the past tense to emphasize that they represent special conditions, in contrast to general conclusions, principles, or truths, which should be described in the present tense:

[3] Linking verbs are intransitive verbs that take a complement; they link the subject to a predicate noun or predicate adjective. (Transitive verbs take an object; intransitive verbs do not; see Appendix 2.) The principal linking verbs pertain to 'state of being' and the five senses:
to be; become; grow; keep; prove; remain; seem; stay; turn; . . . ; appear; look; feel; smell; sound; taste; . . .
A rule of thumb that will generally identify a linking verb is, if you substitute 'seem(s)', the sentence will still make sense. Some of them can, however, also function as transitive verbs:
Linking: He turned pale. ('Pale' is the predicate adjective.)
Transitive: She turned the wheel. (The 'wheel' is the object.)

The Hawaiian hotspot evidently stay*ed* fixed, even though oceans *are* spreading and continents *are* drifting.

(6) Refer to other authors in the past tense; they may since have changed their minds—or even died:

Darwin (1859) argued for evolution of the species by survival of the fittest.

But if you make reference to their work by its title, then because the document still exists, discuss its contents in the present tense:

Suggestions to Authors contains other examples.

5. Anthropomorphism (personification)

Do not ascribe animate characteristics to inanimate subjects, an effect known as 'anthropomorphism' or 'personification'. Some blatant, *but not uncommon* examples are:

The rock suffered (underwent) metamorphism.
The terrane experienced uplift (was uplifted) in the Jurassic.
The abundance of hornblende argues for (indicates, suggests) high water pressures.
This absence of plagioclase calls for (requires) explanation.

Some milder, 'legislative' variants that many people find objectionable are:

This result permits the following interpretation.
This observation allows the following possibility.

The alternatives that we favor here would be to use 'suggests' or 'leads to' in place of 'permit' or 'allow', but some people might still consider the sentences anthropomorphic (see below). Another possibility is to change voice and turn the sentences around:

The following interpretation is consistent with this result.
The following possibility stems from this observation.

Expressions such as 'these data suggest (or imply)', 'this feature indicates', and 'this figure (or experiment) shows (illustrates, demonstrates)'—all of which are commonly used in petrological papers—are debatably examples of anthropomorphism. Like most Earth scientists, however, we find them so convenient, and the apparent offenses of using them so minor, that we are happy to live with them. We have never 'argued with hornblende', nor 'heard plagioclase calling', but when we look at data and recognize certain possibilities or implications, we are disposed to think that data can 'suggest' or 'imply'. If we see that a feature is 'indicative', we suppose that it can also 'indicate'. And when faced with a choice between 'Figure 2 shows that' and 'It can be seen in Figure 2 that', we find the possibility of anthropomorphism the lesser of two evils (although we have actually used both expressions many times).

6. The anonymous 'it'; and 'there is', 'there are', . . .

Statements such as 'it is raining' are commonplace in our everyday speech, but the 'it' has no definite identity and can lead to ambiguity and confusion. Also, the sentences that stem from it are in the passive voice, and, as is typical, they tend to be awkward and wordy:

Awkward: It was deduced from the experiment that the mineral assemblage is stable.
Better: The experiment showed that the mineral assemblage is stable.

We do not say that you should never use the phantom 'it', but use it sparingly.

Sentences with 'there is', 'there are', or 'there were' are also in the passive voice, and they too have the usual traits:

Awkward: There are only a few layers that contain plagioclase.
Better: Only a few layers contain plagioclase.

As used here, 'it' and 'there' are called expletives, a name that also applies to cuss words.

7. 'This', 'that', 'these', and 'those' without an antecedent

These words, called demonstrative pronouns, are useful for maintaining continuity of thought between sentences. In the ways they are used by scientists, however, their reference is frequently uncertain or ambiguous. To avoid this problem, add a noun that will identify the reference (thereby changing the pronoun to a demonstrative adjective):

This *result* is satisfactory.
These *observations* are important to the argument.

An exception in which the reference is clear is:

That is not a satisfactory *result*.

Try, though, not to use demonstrative pronouns and adjectives too frequently. They soon become monotonous.

8. 'That' vs. 'which' (restrictive vs. nonrestrictive clauses)

Use 'that' for restrictive clauses, 'which' for nonrestrictive clauses, as in the examples to follow (note the punctuation):

The house *that Jack built* stands on a hill.
Jack's house, *which was made of wood*, collapsed in the earthquake.
The parts *that had failed* were discarded.
The replacement parts, *which were expensive*, were put into use.

Note that the 'that clauses' are critical to identifying the subject, whereas the 'which clauses' provide additional, possibly important, but less definitive information. The common error is to use 'which' where 'that' is appropriate, so do a 'which hunt' on your manuscript.

Also note that, like participles, 'that' and 'which' can both modify the wrong thing:

Incorrect: The parts of the apparatus *that had failed* were discarded.
Correct: The parts *that had failed* in the apparatus were discarded.

And remember too, they are supposed to modify *specific nouns*, not some implicit concept or general clause or phrase:

Incorrect: The ash bed is paler pink, *which indicates a lesser degree of oxidation*. (Here as in section 3, pink is a predicate adjective, not a noun, and because the 'which' cannot sensibly modify 'ash bed', we conclude that it is being forced incorrectly to cover the thought embodied in the entire preceding independent clause. See section 3 for correct versions of this sentence.)

To use 'which' where 'that' is recommended obviously is not going to cause your manuscript to be rejected. In fact, many people would even argue that the rules given here are outdated. The value of the rules, however, is that, if you can understand and follow them, then not only will your writing be more consistent, but in a small way also, you will understand more about why you are saying what you are saying.

9. Hyphens

Use hyphens in most two-word unit modifiers. For example:

low-pressure conditions (as opposed to 'conditions of low pressure'); 1-cm thickness; 1-atm pressure; self-perpetuating process; mid-Atlantic Ridge.

Exceptions are made for comparatives, superlatives, and '. . ly' words:

the less altered sample; the best preserved example; an unusually swift stream.

In most other cases, British and American conventions differ. By American practice, the use of hyphens is minimal, so there are many words like 'overuse' (which we use in this guide), 'downwelling', and 'sheetlike', but relatively few like 'sill-like' where the spelling necessitates hyphenation. Words with the prefixes 'pre', 'syn', and 'post' are not usually hyphenated, nor are those with prefix 'non':

premetamorphic, syntectonic, postmagmatic, nonideal, nonrestrictive.

By British practice, however, most such compounded words are hyphenated. *Journal of Petrology* is published in Britain, but it accepts either British or American conventions on this matter (just be consistent).

10. Commas, semicolons, colons, and dashes

Commas: Some people write successfully (smoothly) with only a few commas, but most of us need them to keep things sorted out. Having too many yields choppy sentences. All grammar books and many dictionaries contain long lists of uses and examples—and this guide itself amply demonstrates our own preferences and practice. Our only specific comment pertains to lists in which three or more items are separated by commas and the last item (and sometimes more than the last) is preceded by 'and'. We have been encouraged by a couple of publishers (Carnegie Institution of Washington, and Princeton University Press) to put a comma before the 'and', a practice that is not common but that is certainly helpful on occasion.

The rock contains about 60% quartz, 25% albite and orthoclase combined, 10% biotite, and 5% muscovite, plus traces of garnet, magnetite, zircon, and apatite.

Semicolons: As shown by the sentence you are now reading, semicolons can be used in place of conjunctions for tying together closely related independent clauses; they can be used in complicated lists, particularly those in which some items contain commas; and they should precede the 'and' at the start of the last item in such lists.

Colons: As shown to the left, colons can set off subheadings, or they can provide a break before a list. They can also precede the citing of an example: e.g., as here.

Dashes: An abrupt change or suspension of thought—as in this example—can be separated out by dashes—as can afterthoughts. Dashes can also be used before examples like colons— e.g., as here; and before lists, also as here, where they seem to keep the sentence flowing rather than bringing it to a stop like a colon.

We might emphasize here that, although punctuation such as the above outlines the structure of sentences and makes them easier to follow, it rarely in itself corrects awkward, ambiguous or unclear sentences. They generally represent problems of wording, and to avoid them essentially requires an understanding of—or, at the least, a sensitivity to—the functions of clauses and phrases (see Appendix 2 and sections 57–60).

11. Transition words, terms, and techniques

The English language has many words and terms that are not conjunctions but serve, nevertheless, to bridge and smooth the gaps or changes or thought within and between sentences and between paragraphs. It is important to learn to use them if you want your writing to flow and your line of thought to be clear—but do not overuse them. Principal transition words are:

accordingly, again, also, although, apparently, conceptually, consequently, conversely, eventually, evidently, doubtless, finally, first (second, third), furthermore, hence, however, indeed, inevitably, later, meanwhile, moreover, namely, nevertheless, next, nonetheless, now, otherwise, overall, perhaps, possibly, similarly, specifically, still, subsequently, then, therefore, though, thus, too, yet.

Some common transition terms are:

> after that, as a result, at the same time, before then, by concept, by contrast, for example, for this reason, in addition, in any case, in detail, in fact, in general, in particular, in practice, in principle, no doubt, on the other hand, since then, that is.

You will appreciate that these words and word groups have various functions, relating particularly to: (a) result (*therefore, thus*), (b) example (*specifically, in particular*), (c) comparison (*similarly, likewise*), (d) contrast (*however, nevertheless, although, on the other hand*), (e) addition (*moreover, besides*), (f) time (*now, subsequently, before then*), and (g) sequence (*first, next, finally*). Some of the words have similar meanings but differences of connotation—e.g., 'however' is roughly equivalent to 'but' or 'by contrast', whereas 'nevertheless' means 'in spite of what has just been said'. Inexperienced writers commonly pick up one or two transition words (notably 'also' and 'although') and then work them to death, miring the reader in monotony.

In most cases, transition words and terms should be set off by commas. Sentences containing words such as 'however' read better when it is placed at some appropriate intermediate point, or at the end, rather than at the start, even though the bridging is with the preceding sentence. Note in the following example that the 'however' in the middle of the second sentence provides bridging that is equivalent to having 'but' as a conjunction between the first and second sentences:

> The volcanic belt is strongly folded and is cut by several faults. The deformation is not penetrative, however, and the rocks are free of cataclasis.

If you put 'however' inside or at the ends of sentences as a general rule, then as an exception, you can use it at the start of a sentence when you want emphasis—a mild, 'HOWEVER, . . . ' That should not be common circumstance, *however*.

Sometimes effective transitions can be achieved by starting sentences with 'But . . . ' or 'And . . . '. Or with 'Or . . . '.

Transition between (and within) sentences can also be achieved by (1) using demonstrative adjectives (this, that, these, and those) with reference words, (2) using pronouns that refer to antecedents in the preceding sentence, and (3) repeating or keying on certain words in a preceding sentence. *These three methods* are illustrated by italics in the *sentence* that you are reading and in *those immediately below*:

> The ensuing volcanism yielded enormous basalt *flows* that spread over a large part of the drainage system. *They* filled the main valley and spilled into neighboring depressions, blocking off many streams. The individual *flows* commonly have columnar tops . . .

When using a pronoun such as 'they' as above (or 'it'), be sure that its reference is clear (unambiguous). Thus, with 'they', there should be no plural nouns in the preceding sentence except its antecedent. Otherwise, repeat the noun.

Transition between paragraphs is accomplished in similar ways. The method of key words is particularly effective, and sometimes several key words can be developed into the topic sentence of the new paragraph (see section 59). A question at the end of one paragraph can lead to an answer in the start of the next.

12. Parallel structures

Parallel structures commonly yield economy of words, clearer meaning, and pleasing effects. The parallelism is most frequently in phrases, but can also be in clauses and other word combinations, such as compound subjects and predicates. Some of the most valuable uses pertain to descriptions and involve whole sentences and paragraphs:

Phrases: The lava followed *down the mountain, over the road,* and *into the town.*
Clauses: *The eruption began slowly, continued sporadically,* and *ended catastrophically.*

With compound subjects, the individual subjects should have the same form:

Awkward: Augite in large phenocrysts and small grains of olivine are common in the lava.
Parallel: Large augite phenocrysts and small olivine grains are common in the lava.

With compound predicates, be sure the verbs are correct and in the same tense throughout:

Incorrect: Magma erupted on Friday and continued on Saturday.
Nonparallel: Magma erupted on Friday and continued to erupt on Saturday.
Parallel: Magma eruptions commenced on Friday and continued on Saturday.

For items in lists, give parallel information in parallel forms:

Poor: The rock contains abundant quartz, much biotite, and garnet.
Parallel: The rock contains abundant quartz, much biotite, and rare garnet.

Even though the missing information may have little importance, sentences such as the second last can give readers wrong impressions, or throw them off stride and break their concentration. A more exaggerated example:

Poor: Two dikes can be seen—one, 5 m wide, composed of granophyre and pegmatite, is exposed at the top of the mountain; the other is gabbro.
Better: Two dikes can be seen—one, 5 m wide, composed of granophyre and pegmatite, is exposed at the top of the mountain; the other, 2 m wide, consisting of gabbro, crops out in the cirque to the north.

Parallel structure is especially useful for making detailed descriptions and comparisons more readable. For example, if you describe the different minerals in a rock with their features (such as modal abundance, grain size, and habit) always in the same order, then readers can assimilate the information more easily. Or in comparing two rocks, if you deal with their features in parallel groups (say of three), then you do not have to switch back and forth as much. You may even find it helpful to construct successive paragraphs in parallel.

Problematical common terms

13. 'An' hour, 'a' hypothesis

'An' is used with 'hour', 'honor', and 'heir' (and their derivatives), words in which the *h* is silent. Most if not all other *h*-words are used with 'a'—as in 'a hypothetical situation', 'a hierarchy', etc.

14. 'Based on' vs. 'on the basis of'

'Based on' is a past-tense participial phrase, so it is adjectival; 'on the basis of' is an adverbial phrase.

Incorrect: Based on this tiny fossil collection, Smith proposed a new phylum. (Here 'based on' dangles; it modifies Smith, putting him in double jeopardy.)
Correct: On the basis of this tiny fossil collection, Smith proposed a new phylum. ('On the basis of' correctly modifies the verb 'proposed'.)

Another example:

Correct(?): The decision was made, based on sound reasoning. (Here 'based on' correctly modifies 'decision', but the sentence seems a little awkward.)
Better: The decision was made on the basis of sound reasoning. ('On the basis of' correctly modifies 'was made'.)
Better(?): The decision was based on sound reasoning. ('Based on' is a predicate adjective correctly attached to 'decision' by 'was', part of the linking verb 'to be'.)
Best(?): *We* made the decision on the basis of sound reasoning. (Best because the party responsible is identified, and because of the first-person, active-voice construction.)

15. 'Complement' vs. 'compliment'

The first completes; the second is an expression of admiration.

16. 'Comprise'

'Comprise' is a verb that seems to appeal strongly to geologists, probably because it is an alternative to the much used 'compose'. More often than not, though, it is not used correctly, and even when it is used according to commonly cited rules, it sometimes does not sound right. Its proper relationship to 'compose' is popularly described as follows:

> The parts compose the whole. The whole comprises the parts.

If we change voice and turn these sentences around, we obtain:

> The whole is composed *of* the parts. The parts are comprised *in* the whole.

It is *incorrect* to say 'comprised *of*'.

The matter of 'sounding right' is most peculiar. For example, for some reason, this sentence to us seems wrong:

> A rock comprises minerals.

A possible explanation is suggested by the relationship of 'comprise' and 'include':

> A 'whole' comprises *all* parts but includes *only certain* parts.

Thus, in stratigraphy:

> A group may comprise several thick carbonate formations and include a few thin sand beds.

Accordingly, the above sentence that does not sound right may be faulty in that it does not define a 'whole', whereas the following sentence seems alright because it does:

> The rock comprises *five main* minerals.

(The use of the definite article probably also helps.) But remember, the 'whole' is entirely a definition of the moment. In the next sentence, for example, it comprises only 50 of every 100 parts:

> Plagioclase comprises 50 per cent of the gabbro.

17. Correlative conjunctions: 'both . . . and', 'either . . . or', . . .

Correlative conjunctions ('both . . . and'; 'either . . . or', 'neither . . . nor', 'if . . . then', 'not only . . . but also') should be followed directly by the same grammatical form—a verb for a verb, an adjective for an adjective, a prepositional phrase for a prepositional phrase—whatever:

Incorrect: Either the magma was too cool or too rich in silica to be fluid.
Correct: The magma was either too cool or too rich in silica to be fluid.

A principal problem resulting from misuse is ambiguity:

Ambiguous: The layers both became thicker and coarser grained with stratigraphic height.
Possibility 1: Both layers became thicker and coarser grained with stratigraphic height.
Possibility 2: The layers became both thicker and coarser grained with stratigraphic height.

18. 'Criteria, criterion . . .

> Criteria are . . . , criterion is . . . , data are . . . , datum is . . . ; phenomena are . . . , phenomenon is . . . ; spectra are . . . , spectrum is . . . '; strata are . . . , stratum is . . ; tetrahedra are . . , tetrahedron is . . .

19. 'Due to', 'owing to', 'because of'

'Due to' is adjectival, whereas, 'owing to' is adverbial, but because they have similar connotations, they are often used incorrectly for each other. Whichever is right, though, it commonly happens that a better sentence can be produced by substituting 'because of', so we recommend that you examine that possibility:

Incorrect: Due to bad weather, the trip was cancelled. (Here, 'due to' incorrectly modifies the verb 'cancelled'.)
Correct: Owing to bad weather, the trip was cancelled. ('Owing to' correctly modifies 'was cancelled'.)
Better: Because of bad weather, the trip was cancelled.
Correct: The eruption was due to excessive gas pressure. (Here, the phrase, 'due to . . . pressure', is a predicate adjective correctly attached to 'the eruption' by the linking verb 'was'.)
Better: The eruption occurred because of excessive gas pressure.
Correct: The eruption stopped owing to depletion of the water content of the magma. (Here, 'owing to' correctly modifies 'stopped'.)
Better: The eruption stopped because of depletion of the water content of the magma.

20. 'Extremely' vs. 'relatively'

Something described as 'extremely' should be at some limit (highest, lowest, most, least, . . .). What authors usually mean is 'relatively'—e.g., in terms of an implied comparison with some overall population.

21. 'If' vs. 'whether'

'If' applies for one condition (possibly compound); 'whether' is used when two alternatives are involved (one of which may only be implied).

> If we are late and it is raining, then go on by yourself.
> They tried to determine whether (or not) the map is accurate.

22. 'Important', 'interesting', 'reasonable', 'significant'

Things are 'important' only in some context; 'interesting', 'reasonable', or 'significant' only for some reason. Be specific: explain the context; give the reason(s). 'Significant' has both common, qualitative uses and specialized, statistical applications. Be careful not to confuse them; the specialized use requires a rigorous statistical test.

23. 'Infer' vs. 'imply'; 'evidently' vs. 'apparently'

'Infer' means 'deduce by reasoning'. 'Imply' means 'to express indirectly'.

> We see smoke; we infer fire.
> His silence implied consent.

The common error is to use 'infer' when 'imply' is required.

The use of 'evidently' implies that what is being said is supported directly by some observation. By contrast, 'apparently' implies that the support arises indirectly by way of some deduction or inference based on one or more observations. In both cases, the observations should be made clear.

24. 'Its' vs. 'it's'

'Its' indicates possession, as in 'its color'. 'It's' is colloquial for 'it is'.

25. 'Presently' vs. 'currently'

The anomaly is that 'presently' means 'in the near future'.

> We are currently (now) doing this; we will presently (soon) do that.

26. *'Principal' vs. 'principle'*

'Principal' means 'of highest rank' or 'foremost'. A 'principle' is a fundamental truth.

27. 'Quite', 'very'

These words can be effective for emphasis in oral presentations but have little or no value or meaning in scientific writing. Avoid.

28. 'Since', 'for', and 'as' vs. 'because' or 'inasmuch as'

'Since' is a time term meaning 'after', but it is also commonly used (particularly in conversation) in the sense of meaning 'because' or 'inasmuch as'. Like many geologists, we contend that, in a science such as ours in which time relationships are frequently at issue, the latter usage should be avoided because it can lead to ambiguity. The following are not outstanding examples, but consider the alternatives in brackets:

Because [Since] the dam broke, its foundation must have weakened.
Inasmuch as [Since] the rock recrystallized, it had to be hot.
Since [Because] John arrived, it has rained steadily.

Mathematicians invariably use 'since' rather than 'because', but they are presumably doing it within the time frame of their argument—thus: 'since (the time when a particular equation was introduced or derived) the following is true, . . . '. Mathematicians are not usually concerned with geologic time.

If you use 'for' in the sense of meaning 'because', put a comma in front of it to avoid confusion:

He turned back, for the road ahead was rough.

The most common meaning of 'as' is 'while'; thus using it for 'because' tends to be confusing, particularly at the start of a sentence. Avoid.

29. Time and space adverbs

The following adverbs are all valuable for descriptive purposes.

Time terms:

always, occasionally, often, seldom, sometimes, usually.

Space terms:

abundantly, everywhere, extensively, in places, largely, locally, sparsely, typically, widely.

Either context:

broadly, chiefly, commonly, frequently, generally, mainly, mostly, rarely.

'Frequently' is usually cited as a time term, but petrological histograms commonly feature frequency distributions in space, hence we favor the broader use indicated here.

The common error is to use a time term where a space term is appropriate:

Incorrect: The dunite is always partly serpentinized.
Correct: The dunite is everywhere partly serpentinized.

30. 'While' vs. 'whereas'

'While' is a time term meaning 'at the same time as'. 'Whereas' is a connective implying a condition of *contrast*. The common error is to use 'while' where 'whereas' is appropriate. The following examples are all correct (or could be), but note that the third is slightly more specific than the second and, therefore, in principle requires more specific supporting evidence:

Silica is higher in rhyolite than in basalt, whereas magnesia is lower.
Silica increased during the metasomatic event, whereas magnesia decreased.
Silica increased during the metasomatic event while magnesia decreased.

The British sometimes use 'whilst' rather than 'while'.

31. 'Yet' or 'still' vs. 'but'

'Yet' is primarily a time term meaning 'up to the present', and 'still' is sometimes used in that sense. This use can resemble that of 'but', but a distinction can (and, we think, should) be made. The first sentence below is fine, but the next two are not really appropriate:

John is tiring, yet he struggles on.
Plagioclase is altered, yet (but) pyroxene is not.
The olivine is partly serpentinized, still (but) its composition seems unaffected.

Matters relating to petrological terminology and notation

32. Acronyms and contractions

A few acronyms and contractions have been widely used in petrology and geochemistry with great success—e.g., MORB for mid-ocean ridge basalt, REE for rare earth elements, and PGE and PGM for platinum-group elements and minerals. Some have also been valuable in particular studies and have been usefully imitated—e.g. LZa,b,c; MZ; and UZa,b,c for the Lower, Middle, and Upper zones and their subdivisions in the Skaergaard intrusion.

Not surprisingly, however, such successes have also led to excesses and abuses. Some authors have successfully used numerous acronyms by virtue of being accomplished writers, but in following example, others who are not so accomplished have produced results verging on babel. Over the years, as both reviewers and editors, we have seen several manuscripts in which authors defined an acronym such as 'FHI' for the 'Flat Hill intrusion' and then proceeded to use it in almost every other sentence, even though an occasional reference to 'the intrusion' would have sufficed and any confusion with other intrusions could easily have been avoided. The authors thought they were saving words and space, but in fact, they were just trying to compensate for poor writing, and in the end, they actually added to their problems. The use of acronyms seems particularly dangerous when the application is to processes—as in the currently popular 'AFC' for assimilation and fractional crystallization. Processes are invariably indefinite, so the abbreviation is never properly defined, but users either do not realize it, or they forget.

In our view, the best use for most acronyms and contractions is to flag the pertinent terms during the writing process to be sure that they are not used too frequently. Then, after their presence has been minimized by restructuring sentences, convert the residue back to words.

33. 'Cumulate', 'cumulus'

In petrological jargon, 'cumulate' is a noun defined as a name for igneous rocks of a particular kind, and its uses are essentially parallel to those of 'rock'. Thus, we can have 'cumulate layers' or 'rock layers', but *'cumulate rock' is redundant.* 'Cumulus' is defined as the corresponding adjective, so we have 'cumulus minerals' and 'postcumulus processes', but *'cumulate mineral' and 'postcumulate processes' are inappropriate.*

34. Distribution coefficients; Mg-*numbers*

Many names and symbols have been used for the chemical distribution coefficients that are so common in petrology, but some consistency seems desirable. We recommend the following names and notation:

Exchange coefficient, a two-component distribution coefficient, as for Fe and Mg (or FeO and MgO):

$$K_D^{Ol/Liq}(Fe/Mg) = (Fe/Mg)^{Ol}/(Fe/Mg)^{Liq}$$

Partition coefficient, a single-component distribution coefficient, as for Mn:

$$D^{Cpx/Opx}(Mn) = (Mn)^{Cpx}/(Mn)^{Opx}$$

where Ol, Liq, Cpx, and Opx denote phases.

Note: By the above definitions, K_D has the same numerical values whether the element concentrations are in mol.%, cation %, or wt. %, whereas D values depend on the concentration units if the phases do not have the same stoichiometry.

A recent, but now deeply ingrained misfortune of petrology is '*Mg*-number'. It is inconsistently defined as either Mg/(Mg+Fe) or 100Mg/(Mg+Fe), and it is variously, awkwardly, and inadequately denoted as *Mg*#, *mg*#, *mg No.*, or Mg No. If fact, the quantity is not a 'number' at all; it is a '*proportion*'. Our experience is that, handy as the 'moniker' may be in conversation, if one is careful in writing to avoid undue repetition, it is better to use the ratio itself. For thermodynamic treatments, we recommend:

$$X_{Mg} = Mg/(Mg + Fe)$$

with the oxidation state of Fe being defined according to the circumstances (and the phase by a superscript if it is important).

In references to multiple values of K_D or X_{Mg}, use 'K_D values' or 'X_{Mg} values'—*not* 'K_Ds' or 'X_{Mg}s'. By common journal practice, abbreviations are seldom pluralized (see section 69).

35. 'Electron microprobe', 'powder X-ray diffraction'

Use 'electron microprobe'—not 'electron probe' or 'probe'.

Use 'powder X-ray diffraction'—*not* 'X-ray powder diffraction'.

36. 'Enriched, depleted' vs. 'richer, poorer'

Geochemists have popularized the terms 'enriched' and 'depleted' through frequent comparisons of the concentrations of elements and isotopes in rocks with their abundances in various (inevitably abstract) estimates of the average composition of the Earth. 'Enriched' and 'depleted' have many legitimate uses in petrology—for example, in studies of igneous differentiation (where the comparison may be with the inferred original magma composition or between rocks of an apparent cogenetic series) and in discussions of metasomatism (where the standard is usually an apparently original or less altered composition of the same rock formation). By virtue of their popularity, however, the words are frequently misused, almost to the point that the problem is a plague! In most cases, the appropriate words are merely 'richer' or 'poorer', or 'higher' or 'lower'. Commonly, for example, the authors are simply comparing two rocks, and in the absence of independent evidence that they do not have, it is impossible to say whether the rock that is richer in the constituent in question is 'enriched' or whether the one that is poorer is 'depleted'. Often too, there is confusion as to whether the constituent is enriched or depleted in the rock, or the rock is enriched or depleted in the constituent. And in extreme cases, the misapplications can be ludicrous. A basaltic magma will be described as enriched or depleted when the intended application is to the mantle source area of the magma. A mantle peridotite will be said to be enriched without saying in what it is enriched or by what standard of comparison. (In one case, it seemed that the peridotite was enriched in dikes.) Or an olivine cumulate will be described as being *less depleted* in the highly olivine-compatible element Ni than in its parental basaltic magma. We have also heard of a rock with a high value of $^{13}C/^{12}C$ but a low absolute content of ^{13}C being described as 'enriched in $\delta^{13}C$' (the per mil difference of the isotopic ratio from that of a standard).

So remember, 'enrichment' and 'depletion' are *processes*, and if you are tempted to use 'enriched' or 'depleted', ask yourself what process is implied and whether the word is appropriate and justified in that context. And if you use the words, be sure to say *what* is enriched or depleted, that it is something that *can be* enriched or depleted, and that you identify the standard of comparison.

37. 'Include' vs. 'contain'

In petrology, the word 'include' has special meanings: plutons include xenoliths; minerals include other minerals and fluid inclusions. Try, therefore, to avoid the common, everyday uses of the word, because they can lead to ambiguities or wrong impressions:

Poor: The pluton is mostly granodiorite but includes gabbro, diorite, and granite.
Better: The pluton is mostly granodiorite but embodies substantial units of gabbro, diorite, and granite.
Bad: Primary minerals include quartz, feldspar, and biotite. (Ambiguous.)
Good: The main primary minerals are quartz, feldspar, are biotite.

38. 'Geologic' vs. 'geological'; 'petrologic' vs. 'petrological'

There does not seem to be any modern rule for choosing between these terms. We have followed an early US Geological Survey practice whereby natural relationships end with 'ic', and human works with 'ical' (see Anonymous, 1958, p. 159). Thus, we have 'petrologic features' and 'geological maps'. We are told that the 'ical' endings are preferred in British English.

39. 'Horizon' vs. 'unit', 'bed', 'layer', or 'zone'

A 'horizon' has *no* thickness. In geological applications, it is a plane or surface, such as a contact, or a bedding or layering plane. Usually the appropriate word is 'unit', 'bed', 'layer', or 'zone'.

40. 'Intrusion' vs. 'intrusive'; 'volcanic' vs. 'volcanics'

'Intrusion' is a noun—as in 'layered intrusion'; 'intrusive' is an adjective—as in 'intrusive contact'. 'Volcanic' is also an adjective. Some government surveys accept 'volcanics' as a noun, as in 'volcanics and sediments', but in point of fact, most of the 'sediments' that geologists write about are actually 'sedimentary rocks', so why not be rigorous and also write about 'volcanic rocks'.

41. 'Lithology', 'chemistry', 'geochemistry'

'Lithology' is essentially synonymous with 'petrography'. Different rock types or units should *not* be called 'lithologies'. They can, however, be called 'lithologic units'.

'Chemistry' and 'geochemistry' are *disciplines*. Authors often entitle a section of their manuscript 'Whole-rock Chemistry' when they mean 'Whole-Rock Chemical Compositions'—or, 'Whole-Rock Major(Trace)-Element Relations(Variations)'. As a discipline, geochemistry encompasses isotopic as well as chemical relationships. Often manuscripts have one section called 'Geochemistry', devoted entirely to whole-rock chemical variations, and another entitled 'Isotopic Relations'.

42. 'Most Fe-rich', 'least Fe-rich', . . .

Try to avoid terms of this type. 'The most Fe-rich rock' presumably is 'the rock richest in Fe', and 'the most Mg-rich rock' should be 'the most magnesian'. But 'the least Fe-rich rock' carries a hint of ambiguity. Is it the same as the 'most Fe-poor rock'? We think that both would be better described as 'the rock poorest in Fe'—*if that is what is really meant*. But often authors are actually referring to ratios such as Fe/Mg or Fe/(Fe+Mg), in which case 'the most Fe-rich rock' might have the highest Fe/Mg but be relatively low in Fe itself. If you mean percentage content of Fe or Mg, be sure your intention is clear. If you mean a ratio, say so.

43. 'Phase' vs. 'mineral phase'

A mineral *is* a phase; 'mineral phase' is redundant. An exception applies for broad discussions or comparisons, as in 'mineral, melt, and gas phases'.

44. 'Phase' vs. 'rock unit, variant, or facies' or 'stage'

At one time, 'phase' was widely used in petrology in reference to the compositional 'units', 'variants', or 'facies' of igneous intrusions, presumably with the implication that these units represent different 'stages' of differentiation. Nowadays, though, the word is deeply entrenched in the sense of 'phase equilibria', where a phase is a solid, liquid, or gas. It seems advisable, therefore, to avoid the older usage.

45. Ratios and slashes

Use 'Th–U ratio', or 'Th/U values', or 'Th/U', but *not* 'Th/U ratio'. The last is redundant.

Use Na/(K + Na)—*not* Na/K + Na. The latter would not give a correct answer in your computer.

Some authors like to use slashes to distinguish alternative possibilities—and some people deplore the practice, claiming that slashes should only denote ratios. We concur with the latter group, but mostly because slashes are so often ambiguous or inaccurate. A simple example is 'and/or'; a more complicated one is 'assimilation/fractional crystallization'; and a particularly popular case is 'Cretaceous/Tertiary boundary'. In place of the first, we might use 'and(or)', but only if we could not find alternative wording in which the combination of conjunctions was not necessary. With regard to 'assimilation/fractional crystallization', it is not clear what the slash means. Did the assimilation occur above the fractional crystallization? Was it superimposed on it? Or does the slash itself now mean 'and(or)'? As for the third example, if it were read as a ratio, it would imply that the Cretaceous was *above* the Tertiary—not a normal stratigraphic arrangement. 'Cretaceous–Tertiary boundary' would certainly be more accurate.

46. 'Rocks' vs. 'rock bodies'; 'minerals' vs. 'mineral grains or crystals'

Geologists frequently speak (for example) of 'kimberlites' when they mean kimberlite *dikes, pipes,* or *diapirs*; of 'basalts' when they mean basaltic *lavas* or *flows*; and of 'peridotites' when they mean peridotite *lenses* or *bodies*. Similarly, they say 'olivines rimmed by pyroxene' when they mean 'olivine *grains* (or *crystals*) rimmed by pyroxene', and 'opaques' when they mean 'opaque *minerals*'. We have no illusions of being able to break these speech habits, but in written text, authors should recognize the lack of precision and that it might cause confusion. Ideally, the rock and mineral bodies should always be specifically identified. The plural form of a rock name should probably be reserved for reference to its variants—e.g., 'basalts' might refer to an association of alkaline and subalkaline basalts in one situation, or to an affiliation of tholeiitic and high-alumina basalts in another. And similarly, the plural forms of mineral names should probably be reserved for their variants or species—thus, 'pyroxenes' might mean augite and hypersthene in one case, or orthopyroxene and pigeonite in another.

47. 'Rocks' vs. 'magmas'; 'magmas' vs. 'melts' or 'liquids'

In igneous petrology, the names of rocks (particularly of the volcanic types) are commonly also applied to the magmas from which they solidified, and confusion often results. For example, authors will write about basalt *the rock* in one sentence, and basalt *the magma* in the next, without specifically identifying them or explaining that they have switched. Try,

therefore, always to make the distinction—as a rule, by identifying the magma, as in 'andesitic magma' or 'kimberlite magma'.

Other ever-recurring problems concern the distinctions between 'magma', 'melt', and 'liquid'. By its traditional definition, 'magma' is molten rock material, but it can also embody crystals, rock fragments, and gas bubbles. Thus, if the liquid is the part of interest, it should be specifically identified. It is properly called 'melt' if the topic concerns the formation of the magma by *melting* processes, but if the topic pertains to crystallization, assimilation, or related processes occurring under cooling conditions, then 'magmatic liquid' (or just 'liquid') is more appropriate.

48. 'Theory', 'concepts', 'hypotheses', 'interpretations', and 'models'

Probably little of purely geologic or petrologic origin can properly be called 'theory'. Most of our 'theories' are really 'concepts', 'hypotheses', 'postulates', or 'interpretations'. In general, then, 'theory' should be restricted to material (usually involving equations) stemming from fields of chemistry, physics, or mathematics, such as thermodynamics, kinetics, fluid dynamics, or statistics. If you are tempted to say 'in theory', consider first whether you actually mean 'by concept' or 'in principle'.

'Model' has been widely used in recent years as a substitute for any and all of the above words, but particularly for 'interpretation'. But almost invariably in such cases, authors are obviously using it because they do not really believe the interpretation they are advancing and they are trying to shed the responsibility. If the interpretation is wrong, it's the model's fault, not theirs! These same authors frequently also claim that their 'model' (interpretation) has 'predicted' certain observed features, when in fact, the most that can be said is that the interpretation is consistent with these features.

Our contention is that a proper geological model should have an experimental theoretical or observational basis that is *independent* of the problem under consideration so that it can be used as a guide to interpretation. Thus:

(1) A liquidus fractionation path on a phase diagram can be a chemical model of the crystallization differentiation of magma.
(2) An experimental tank of convecting aqueous solutions can be physical model of magmatic convection.
(3) A solution to the heat flow equation can be a mathematical model of the cooling of an intrusion.
(4) Thermodynamic solution models can be used to systematize composition–temperature–pressure relationships in minerals.
(5) A Rayleigh fractionation equation can be used to model (simulate) chemical or isotopic relations.
(6) A statistical 'least-squares mixing calculation' relating the compositions of two cogenetic igneous rocks by way of the minerals they contain can yield a model fractionation assemblage.
(7) One geologic process can be used as a model for another—e.g., the foundering of the crust of a Kilauea lava lake has been described as a model of ocean-floor subduction.
(8) Visually simple concepts based on observation or reasonable inferences can sometimes be useful models for describing much more complex phenomena—e.g., the Bohr model of the atom.

We recommend that you try to choose your models by these standards.

49. Unimpressive, misused, and overused words

There are various words (and the odd nonword) that authors often misuse, overuse, or use because they apparently think the words are impressive or clever. Most of these words are acceptable in appropriate circumstances (for example, if used occasionally for variety); but

when used frequently, they can seem pretentious and become irritating. Some principal examples (with alternatives) are:

> ascertain (determine, establish, . . .); cartoon (schematic diagram); constrain (control, restrict, define, limit, . . .); essentially (generally, commonly, practically, . . .); generate (produce); the nonword 'irregardless' (regardless, irrespective); ongoing (continuing, current); portion (part); scenario (postulated circumstances); show (demonstrate, illustrate, suggest, indicate, imply); signature (characteristics); utilize (use).

We have not been much bothered by 'constrain' or 'essentially', but we note that 'essential' can mean 'necessary in principle', whereas 'practical' means 'functions in reality', a difference that is often relevant. 'Cartoon' tends to be degrading, not just to the diagram to which it is applied, but to the entire paper in which it occurs. In most applications, 'portion' is obviously used because it seems more impressive than 'part', but a 'portion' is an 'allotted share' (like a piece of pie), whereas 'part' is completely open to definition. 'Scenario' should be used carefully and probably not more than once in a manuscript, because it is rather 'showy'. The word 'show'—as used in expressions such as 'these features show . . . '—is not only overused, it commonly also represents an overstatement in terms of the evidence for its application. A word such as 'suggest', although 'weaseling', is usually more appropriate. 'Utilize' has a long-standing reputation as a pretentious word, and 'ascertain', 'generate', and 'signature' fall in the same class.

Manuscript organization and content of the parts

50. General outlines

Every manuscript requires specific organization dependent on its subject material, so we do not want to give the impression of trying to dictate on this matter.[4] Geological manuscripts are notoriously difficult to organize, however, so some broad guidelines may be helpful. As a rule, the most effective approach for the major features under consideration is to try to progress from description to interpretation through the manuscript as a whole. Minor features, on the other hand, are usually more effectively interpreted as they are described because that avoids having to repeat description later. Several field-oriented manuscripts that we have processed were improved significantly by rearranging them to fit the following general outline:

Introduction
  Describe the problem, the study area
Field Relations
  Define principal rock units; describe their relationships
Petrographic Features
  Classify and describe the important rock types
Mineral Compositions
  Present data; calculate intensive parameters (T, P, f_{O_2})

[4] A prosaic outline that should have some appeal for geologists is to liken the manuscript to a fluvial drainage system. Thus, tables and figures are source regions of Data, and the text corresponds to the flow of water. First-rank headings lead off descriptions of the major streams of Observation and Evidence; lower-rank headings delimit their tributaries. The streams come together in the delta of Discussion, where the sediments of discovery are sorted and deposited as Conclusions on the edge of the ocean of knowledge (which we are trying to fill in). At least part of the research has involved reworking of the sediments of other people's discoveries as represented in the References. Because the streams of Observation and Evidence have to be described in linear sequence, their sequencing is a matter of prime concern, and it is here that the transitions from visual observation to analytical measurement to computational or model inference are important considerations. Like streams, the writing should flow, and the text should always have direction.

Whole-Rock Compositions and (or) Isotopic Relationships
  Present analytical data; describe the important features
Genetic Considerations and Discussion
  Present models; give interpretations
Conclusions

In this arrangement there is a general progression from observation to interpretation, and the observational information itself leads from things that one can see physically to features that can only be defined analytically. The one notable problem is that the whole-rock chemical data are sometimes needed at an early stage for classification purposes. A practical solution is to show the data graphs that are pertinent to classification at this early stage, while saving the data themselves and graphs that are more relevant to description and genetic considerations until later in the manuscript.

Experimental studies are generally easier to organize and describe than field studies. The following traditional outline is commonly appropriate, at least in a broad way:

Introduction
  Explain the reasons for the study and your objectives
Experimental Methods
  Describe apparatus, materials, typical experiments, special procedures
Results
  Present data; describe the important features; give theoretical analysis
Applications
  Examine your findings in relation to pertinent petrological problems
Conclusions

We might note in passing, though, that there can be philosophical problems associated with the above kinds of organization schemes. Scientists like to give the impression of making their discoveries by a succession of events involving perceptive analysis of a problem, careful experiments and observations, and insightful processing of their data, whereas, in fact, they frequently just stumble onto them (sometimes in ways that they do not even want to admit), and then they work out rational solutions in reverse. Fortunately or unfortunately, this problem is not usually a concern in petrology.

51. Abstract and introduction

The abstract of a manuscript should be an overview of its contents, not necessarily a description, and it should be informative. Do not make statements such as 'Experimental results are discussed (period).' The introduction will depend on the subject material, but as a rule, it should define the problem or the objectives of the study and perhaps give an indication of the findings. It should *not* be a lengthy review of previous work. If such a review is necessary (usually it is not), then it should be a separate section.

The length of the abstract should be in proportion to the length of the text, and two pages should generally suffice for a *long* manuscript. The introduction should not exceed about a page of typescript. In the writing process, leave the abstract and introduction until near the end, because final manuscripts are usually different from initial expectations.

52. Methods of investigation

Give descriptions of all field, experimental, and analytical methods. If they are brief, work them into the text at appropriate places; if they are lengthy, put them in one or more appendices. Up to now, field methods have not often been reported in *Journal of Petrology* papers, but for reader evaluations, they can be just as significant as laboratory procedures, and sometimes more so. We have had authors refuse to admit how much—or how little—field work they have done. Therefore, briefly describe the nature of your field work (extensive

detailed mapping, reconnaissance sampling, or what?) and give an indication of the amount of time spent.

53. Descriptive sections

The content of these sections depends, of course, on the subject material, so not much can be said about them. Our one comment concerns manuscripts based on field studies. Typically nowadays, they present large numbers or rock and minerals analyses, but much too frequently they contain almost no field or petrographic information. In a couple of cases, the rocks were even presented as being 'igneous' when it was clear that they were at least partly metamorphic, and on occasion, we have had astonishing difficulty convincing authors that the rock descriptions were actually important and necessary. We emphasize, therefore, that without a backing of field and petrographic information, most geochemical data are almost meaningless. No one wants long, boring descriptions, but the reader needs enough information to get some feel for the nature of the rocks and their relationships in the field and under the microscope. See sections 57–64 (particularly to 61) for suggestions on writing descriptions and handling detail.

54. Discussions and concluding statements

Do not introduce new data in any section titled 'discussion', and do not introduce new discussion or data under 'conclusions'. Nor should a concluding section be a repetition of the abstract. It should highlight only conclusions, perhaps in a numbered list, but among them might be questions or recommendations relating to unanswered problems or future work. In a short paper, a section on conclusions may not be necessary.

55. Footnotes

Journals tend to discourage the use of footnotes, and *Journal of Petrology* is no exception. The common view is that something worth putting in a footnote is worth putting in the text. Footnotes can, however, be useful places for highlighting information that is important to the main argument in the text but that does not fit in readily or might otherwise be overlooked. (Let's face it, readers often read footnotes more carefully than the text because they are shorter.) Use them sparingly, however.

56. Diagrams, photographs, and figure captions

Every diagram and photograph should be used (cited) *at least once* in some *significant* way. Our experience is that authors who have done numerous rock and minerals analyses often show graph after graph of their data without saying a word about them beyond the captions (if even there). If a diagram does not have a specific purpose, then leave it out.

Except for comparisons within a data set, most plots of rock and mineral compositions are not usually meaningful unless they include some internal framework for comparison or reference, such as field boundaries for data from other rocks, control boundaries from an experimental study, or a theoretical reference system.

Field-based studies should generally include maps of pertinent geologic relationships, and we encourage the use of field photographs—in reasonable numbers.

The caption for a figure should comprise one or more concise, informative *sentences* describing all of its parts. (Do not just say, for example: 'Plot of MgO vs. SiO_2'. Identify the data.) Also, because the caption is directly below or adjacent to the figure, it is sometimes the best place to describe particularly complicated relationships in detail. It can also occasionally be used to repeat some limited part of a text description if emphasis is needed—but keep repetition to a minimum.

The major problems and the writing process

57. Irrelevant material; repetition; lack of coherence and unity; awkward wordy, ambiguous, unclear, and inaccurate sentences

These problems are rampant in the manuscripts that we see, and there seems no simple way to avoid or correct them. We have occasionally had to ask authors to shorten their manuscripts by 20–40%, and they have usually done it without complaint, so they must have at least suspected that some of the material was unnecessary. Most manuscripts can be shortened by about 10% without harm by cutting a word or phrase here, a clause or sentence there. The process is time consuming, and authors obviously do not like to do it, but they should. Otherwise, the principal technique for achieving conciseness is *subordination.* Essentially, you take important information from one sentence and make it a subordinate part of another (e.g., as a dependent clause or participial phrase), eliminating a few words in the process (see section 60). The method does not yield major reductions, however.

Repetition seems to be a remarkably sensitive indicator of weak writing. We find that, if the names of elements or minerals are repeated more than three or four times in a paragraph through any appreciable part of the text, or if a rock name is repeated more than four or five times a page for several pages, then the manuscript generally has a whole variety of writing problems. Essentially what is needed is a major effort to improve sentence structure and paragraph organization along the lines described below.

Lack of coherence and unity,[5] and awkward wordy, unclear, ambiguous, and inaccurate sentences are the most discouraging problems that we encounter. They are common in the works of authors at every career stage, from predoctoral students producing their first paper to senior scientists (even editors) with long publication lists, including even books. Some manuscripts seem scarcely more than first drafts, because it is obvious in sentence after sentence that the authors cannot possibly be saying what they mean, even though what they mean may be essentially correct. We have tried on occasion to deal with these problems by suggesting improvements to limited sections of the text with the hope that the author(s) will carry on from there. But this approach seldom works; the limited suggestions are usually followed, but the rest of the text comes back almost unchanged. To suggest improvements to the whole text is a formidable task—and inevitably, it is offensive to the authors. And it cannot usually be done effectively in just one round of editing; repeated revisions are commonly necessary.

The best suggestion that we can make on these problems is that authors try to write their first drafts in the simplest of sentences, and then develop and smooth them through repeated revision. Accomplished writers (be it in literature or any other field) will invariably proclaim the power of the *simple declarative sentence*—the sentence that makes a single statement briefly and directly—and our proposition is that, if such sentences are used almost exclusively in a first draft, then it should be more obvious when something is being repeated unnecessarily, and the sentences can be more easily resequenced to improve coherence and unity. Then, after these steps are taken, the writing can be smoothed by combining some of

[5] To illustrate the meanings and differences of coherence and unity in a paragraph, we might use the homely example of a jigsaw puzzle. Coherence pertains to the cut of the pieces of the puzzle and how well they lock together—or to the logic of a paragraph in terms of the sequencing of its sentences. Unity pertains to the picture portrayed by the assembled puzzle—or to the story told by the paragraph. Unity is lacking in the puzzle if some pieces are missing or out of place, or if pieces from two or more pictures are mixed together. It is lacking from a paragraph if there are conceptual gaps, if some of the sentences are irrelevant, or if the paragraph mixes two or more stories or arguments.

the sentences with appropriate conjunctions and transition terms, by compounding predicates, and by substituting pronouns for nouns; and the presentation can be shortened and focused by subordination. This approach is illustrated in section 60, where it is used together with techniques of paragraph construction described in section 59.

58. Basic requirements: vocabulary and the skill to use it; care; constructive self-criticism

Chances are, you do not realize how large your vocabulary is. We all understand many more words than we ever speak, and we all speak many more than we ever use in writing. Developing an active vocabulary requires an interest in words and their meanings and connotations, and in the variety of ways in which they can be used. So be alert for applications that might be useful to you. A thesaurus attached to your word processor is a handy utility, but for developing sensitivity to words, there is no substitute for extensive reading of well-written material—from any field.

Being too careful can be a fault, but it is not common in writing. An extra round of revisions never seems to hurt.

Constructive criticism of one's own work requires the right attitude as well as a knowledge of what is good and bad in writing practice. If someone tells you that your writing is deficient, don't take offense; they're probably right. What is important is to learn to recognize the deficiencies yourself. Scientists rarely become outstanding writers, because their subject material is too limiting, and they do not get enough practice. A good test of your skill is to read occasionally some text that you wrote just a few months previously. If you are like us, you will often be impressed by how opaque it seems now.

59. Paragraph construction

In principle, the major problems enumerated above are matters of logic; in practice, they are problems of *composition*. Paragraph construction is arguably the most important single aspect of composition. If you can produce a good paragraph—and, perhaps more importantly, if you can recognize when you have *not*—then you are well on your way. Production of a whole manuscript is essentially an extension of the same techniques and logic.

Paragraphs vary enormously in character, however, so the logic is not simple, and any explanations that we can offer are not likely to make you adept at constructing them. Good writers seem to define and organize elegant paragraphs almost instinctively; poor writers flounder with even the simplest.

The one construction rule that is always cited is that a paragraph should support or develop a *single idea* defined by a *topic sentence*. In most cases, the topic sentence is the first sentence, and commonly the text develops from it by progressing *from the general to the specific*, ideally with all sentences keeping to the topic by way of their sequencing and transition words and through references to *key words or phrases* in the topic sentence. The pattern is enormously variable, though. (Writing is boring when it is not.) The topic sentence sometimes does not appear until the middle, or even the end of the paragraph, and other methods of development are frequently used.

Probably the most common paragraph construction problems are lack of *coherence and unity*—the line of thought is disjointed, the text rambles, things just don't hang together. In some cases, particular sentences belong in some other paragraph; in others, the sentence sequencing is inappropriate, and shuffling is needed. Often the problem is a matter of maintaining continuity of thought by way of appropriate conjunctions, transition words, or key words or phrases, or by continuing the same verb tense. Hypothetical examples of these problems are invariably lengthy, however, and they always seem a little silly, so they are not illustrated.

One book on technical writing (Reisman, 1962) lists seven ways to develop paragraphs from topic sentences: description, argumentation, enumeration, comparison and contrast, details in sequence, definition, and example. It is difficult to judge whether this classification is realistic or complete, but certainly if it is, some of the ways must have many variations. However, on the premise that any guidelines are better than nothing, we give some partial examples below. The first sentence in each case is the topic sentence; key words are italicized; and transition words are prominent. In (1), (4), and (7), the topic sentence defines the general situation; the ensuing text gives specific information. In (1), modal abundances and grain sizes are described in parallel for the different minerals.

(1) Description:

The gabbro is *melanocratic* and *coarse grained* with strong *planar lamination*. Typically it contains 40–45 *modal* % augite, 15–20% hypersthene, about 10% titanomagnetite, and *only* 20–25% plagioclase. Olivine occurs sporadically, locally amounting to 5–10%. The *grain size* of the pyroxenes is generally 1–2 cm. The magnetite is mostly aggregated in irregular clots, about a centimeter across; and the plagioclase occurs as subhedral laths, commonly 2–3 cm in length. By comparison, the olivine grains are small (1–5 mm), and they commonly have irregular shapes because of resorption. The *lamination* is mainly defined by the plagioclase laths, but the pyroxene crystals also show some parallel alignment. . .

(2) Argumentation:

This interpretation leads to similar *problems*. The rock does not contain enough iron; it is too rich in . . . and too poor in . . . Furthermore, it . . . And there are . . .

(3) Enumeration:

The metasomatism occurred in *three stages*. In the first, . . . In the second stage, . . . And in the third stage, . . . (If you announce a specific number of points as here, be sure that they are all readily identifiable.)

(4) Comparison and contrast:

The *two units* are *similar* in their *major element* compositions but *differ* greatly in their *trace* constituents and *isotopic* relations. *Both* are rich in SiO_2 and Al_2O_3 and poor in CaO and Na_2O, and *both* carry moderate amounts of MgO, FeO, Fe_2O_3, and K_2O. *But* the *upper* unit is rich in Ti, V, and Ba, *whereas* the *lower* is . . . And similarly in *isotopic* ratios, the upper unit is . . . , *but* the lower is . . . (Some interpretation or evaluation of these relationships should follow.)

(5) Details in sequence:

In the next part of the study, *melts* were *crystallized* at controlled *cooling rates*. In a typical series of experiments, five charges of a chosen composition were held at a temperature 5 °C below its liquidus for 20 h to ensure equilibrium partial *melting*. One charge was then quenched and examined microscopically to be sure that a few *crystals* had survived as seed. Then, if plagioclase was the residual *solid*, the other charges were *cooled* at a rate of 5 °C/h and . . . If, on the other hand, the liquidus phase was diopside, the *cooling rate* was . . .

(6) Definition

The general *characteristics* of the magma can now be defined qualitatively. The abundance of olivine in the cumulate succession implies that silica was low, and magnesia high. The prevalence of hornblende indicates a high water content, and . . .

(7) Example: (Here, 'pelite' and 'sandstone' serve as second-order key words.)

None of the *formations* appears, however, to have changed significantly in composition during the metamorphism. For examples, *the Jughead pelite* has exactly the same chemical features at sillimanite grade as at chlorite grade, and *the Topnotch sandstone* shows as much variation in a single outcrop at any one grade as it does between outcrops at the extremes of grade. The *pelite* is

everywhere rich in . . . And the *sandstone* is . . . Furthermore, both *formations* are . . . Another example is the *Tipsey basalt*. It shows. . .

All this is *not* to say that, when you are writing, you should construct your topic sentence, pick key words, and then proceed dutifully to construct the paragraph around them. That would be drudgery and a sure way to obtain a boring product—and it would probably lead to writer's block. We recommend that you write down what you have in mind as fast as you can. The flow of your words and ideas is likely to be best that way. Then come back and check that you have topic sentences, that you have kept to the central thought throughout each paragraph, and that you have made effective use of key words, transition words and phrases, parallel structures, and so forth. Some books suggest that, if a paragraph is particularly complicated, a rough outline may help to get its organization right. We are certainly no experts on these matters, but our impression is that, as with all techniques, if you understand the principles, then with practice you learn to use them automatically and to make more sophisticated applications.

One last comment on paragraphs concerns their length. Having many short paragraphs may signify undeveloped ideas and poor organization—or you may be chopping up your ideas and concepts and spoiling their overall coherence or unity. At the other extreme, readers get lost in paragraphs that are too long. Try to vary paragraph lengths in reasonable ways, based on topic sentences. With word processors, testing alternatives is easy.

60. Subordination and sentence sequencing

Subordination is a writing technique whereby the less important observations and thoughts in a sentence are given reduced emphasis by putting them in grammatically subordinate positions—e.g., as modifiers, dependent clauses, or participial phrases. Subordination makes writing more concise, and it can be used to focus the argument of a paragraph. Sentence sequencing commonly determines the coherence of the information or argument, and it can also be used to highlight important information in that the first and last sentences in a paragraph tend to attract the most attention. Skillful use of subordination and sentence sequencing are marks of a mature writer.

The following three paragraphs all have the same content, but they have rather different emphases because of differences of subordination and sentence sequencing.

> The Skaergaard Intrusion is a gabbroic pluton in East Greenland. It is renowned for magnificent layering and marked compositional differentiation. It has been the subject of intensive scientific research for almost 60 years. The layered rocks have an exposed thickness of approximately 2600 m. Three distinctive stratification units known collectively as the Triple Group occur about two-thirds the way up this succession. Each unit is highlighted by a prominent leucocratic layer a few meters thick. In 1988, a Canadian mining exploration company called Platinova Resources discovered a stratigraphic zone at the base of the Triple Group in which gold occurs in economically interesting concentrations. This zone may someday be a major ore deposit. It extends across much of the intrusion and is generally 1–2 m thick.

> The Skaergaard Intrusion, a gabbroic pluton in East Greenland renowned for magnificent layering structures and marked compositional differentiation, has been subject to intensive scientific research for almost 60 years. About two-thirds the way up its 2600-m-thick exposed succession of layered rocks there are three distinctive stratification units, known collectively as the Triple Group, each highlighted by a prominent leucocratic layer a few meters thick. In 1988, a Canadian mining exploration company called Platinova Resources discovered a stratigraphic zone at the base of the Triple Group containing gold in economically interesting concentrations. This zone is generally 1–2 m thick, and because it extends across much of the intrusion, it may someday be a major ore deposit.

> The Skaergaard Intrusion, a gabbroic pluton in East Greenland that has been the subject of intensive scientific research for almost 60 years, is renowned for magnificent layering structures and marked compositional differentiation. In 1988, a Canadian mining exploration company called Platinova Resources discovered that the intrusion also contains a stratigraphic zone carrying economically interesting concentrations of gold. This zone is generally 1–2 m thick and extends across much of the pluton, hence it may someday be a major ore deposit. The zone is situated at the base of the Triple Group, a succession of three distinctive stratification units, each highlighted by a prominent leucocratic layer a few meters thick, situated about two-thirds the way up the 2600-m-thick exposed section of layered rocks.

In the second and third paragraphs, some of the sentences are longer than is perhaps desirable, but our objective here is to illustrate subordination techniques, not to produce the best sentences.

The first paragraph has almost no subordination. Most of the information is given equal emphasis in independent (main) clauses presented as simple declarative sentences. Everything is reasonably clear, but the writing is jerky, the information seems uncoordinated, and a topic sentence is difficult to identify. In the second paragraph, about half the first sentence is a subordinate (dependent) clause, and the independent clause ('The Skaergaard intrusion has been the subject of intensive scientific research for almost 60 years') gives the paragraph a historical tone. The topic sentence begins, 'In 1988, . . .' and is concerned with the discovery of the ore zone. The second sentence sets up the topic sentence, and the last sentence ends with a 'punch line' that puts an overall emphasis on the economic significance of the discovery. The third paragraph has essentially the same topic sentence, but the historical part of the first sentence and the economic punch line are both subordinated, and the emphasis is on the geologic setting of the ore zone.

As noted in section 57, we think the approach illustrated above—of starting with simple sentences, as in the first paragraph, and then converting them into text that reads more smoothly, as in the second and third paragraphs—is a good way to produce coherent paragraphs free of repetition and ambiguous and inaccurate sentences. To use this approach effectively, of course, one needs to understand the functions of principal and subordinate clauses and prepositional and participial phrases, and to know the basic structural characteristics of simple, compound, complex, and compound–complex sentences (see Appendix 2). The obvious weakness of the approach is that it is too structured or formalized. Writing is generally done better if it is more spontaneous. So we say, write in whatever way suits you best, but practice the method suggested here enough that, to a degree at least, it becomes a skill, and you can use it when you need it.

61. Detailed descriptions and discussions

One of the frustrating truths of petrological studies is that many detailed measurements and observations commonly have to be made on rocks and in experiments in order to define pertinent general relationships, but the details themselves have only limited interest. Reliable observations and data should, of course, be documented as much as possible in tables and diagrams (see section 71), but the question is: To what extent should they be described and discussed? The answer obviously depends on the material, but the concern is that, when descriptions are too comprehensive, the effect is the age-old problem of the trees and the forest: the emphasis on specific observations tends to obscure the overall picture. We see many examples of this problem, and they tend to remarkable extremes. At the one extreme, almost every other sentence either contains or is parenthetically interrupted by quantitative information—such as modal data, mineral compositions, element abundances, mineral assemblages, estimates for intensive parameters, model parameters, even sample numbers. In experimental studies, techniques and minor observations are described in painful detail, and quantitative data are sometimes cited to more figures than can possibly be significant.

At the other extreme, similarly comprehensive descriptions and comparisons are made, but quantitative data are never cited; all the information is qualitative—things 'increase' or 'decrease', or they are 'higher' or 'lower'—and if readers want even a rough range for some variable, they are obliged to forage through tables and find it for themselves.

In the case of discussions, there is often an ironic situation that simple, non-controversial interpretations are explored and supported at great length, whereas major, contentious ones are skipped over almost parenthetically.

And a common flaw of both description and discussion is repetition. Thus, in field-based studies, particular constituents of a rock are sometimes mentioned six or eight times in a single paragraph, and the names or designations of specific rock types may recur eight to a dozen times per page through large sections of the manuscript as the rocks are compared and contrasted in terms of a seemingly endless list of constituents, parameters, or possibilities. And commonly there is no indication or explanation of why the data are significant or where the description or discussion is leading. Faced with so much uncoordinated information, even the most dedicated readers soon bog down and lose interest.

Because these problems depend on the material, it is difficult to make recommendations that might be broadly useful. In relation to field problems, though, it is perhaps worth emphasizing that much of the processing of information that goes on in geology is effectively concerned with sorting, categorizing, and collating observations and data. Thus, as we explore rocks in terms of their many characteristics, we are searching for *natural* patterns and associations. We are seeking *order* in subject materials that at first sight often appear chaotic, with the hope that order will reveal relationships pertinent to geologic history and petrogenetic process. A prime measure of success of this effort, then, is whether we can describe in an orderly (and convincing) way what we have learned—and what is still in doubt. From the text, qualified readers should be able to obtain an overview of the results with relative ease, and an unambiguous detailed picture with reasonable effort. They should not have to assimilate all the detail and sort it out themselves!

What seems to be required, then, is that the authors identify and emphasize the *general* patterns in their data and observations, and the *significant* departures from them, and, in the briefest possible way, give some indication of why their observations are important (be it only to say that they are 'general' or 'typical' features). The judgements involved as to what is significant will depend on the problem and the authors' view of it, and they are not likely to be easy. There is always the possibility, for example, that an observation that appears minor at first sight has major significance.

In general, *diagrams and graphs* are especially critical to this problem, because they can illustrate general patterns in important subsets of the data while also showing detail. They can also be a problem themselves if they are too complicated, but in principle, they have two end-member functions that are both obviously valuable. One is to portray observations and data, in which case the related text should be a description of the illustrated relationships; the other is to support the text, thereby making it simpler to write and understand. Original geological maps and phase diagrams are prime examples of the first function in that they are direct records of observational data. More common, though, are plots of analytical results, and for them, the choice of parameters can be critical. (For example, the chemical variations in tholeiitic volcanic rocks can usually be effectively illustrated in plots against MgO, but the variations in calc-alkaline rocks seem better represented against SiO_2.) Important too is a reference framework within the graph. Analytical data are generally more informative when they are portrayed on a background of comparative data, or on some experimental or theoretical framework. Particular care should also be taken in labelling graphs and writing

the captions. Diagrams serve their scientific purpose much better if they are convenient to the reader (see sections 56 and 74).

Diagrams to support text should, of course, be simpl*ifying*. For example, if you are dealing with a complex array of rock types, it may be helpful to illustrate their observed or inferred relationships on a schematic 'family tree' before setting out to describe them. The reader then has an overview, and the descriptions can be directed to documenting and developing concepts represented in the diagram. Interpretations arising out of data descriptions and analyses are often best portrayed in *semi-quantitative*, *semi-schematic* diagrams. We emphasize 'semi'- because truly quantitative representations tend to be too complicated (if not impossible), and completely schematic interpretations often seem to have little bearing on reality.

The text that does describe detail should usually be organized to proceed *from the general to the specific*—be it from section to section, within sections, or within paragraphs. In other words, try, without being repetitious, to give the reader some indication of what is coming next (and why) before getting into the detail. (Summary tables may be helpful.) When you are describing data, direct the reader's attention to the pertinent tables and figures at the start of a section and to each specific diagram at the beginning of the paragraph or sentence as you set out to describe or discuss it. (Don't hold off until the end of your description and then say: 'All these features can be seen in Figs. . . .'.) Use parallel structures to organize descriptions and to minimize switching back and forth in comparisons. And try to keep the description 'moving' by incorporating figure numbers and quantitative data into the flow of words, rather than interjecting them parenthetically (as between commas, dashes, or actual parentheses). In referring to the works of others, recognize that the citation must go where it is needed for accuracy, but try also to work it into the sentence structure so that the authors' names are part of the word flow. When you do put references in parentheses, do it at the ends of sentences or between clauses so as not to disrupt the continuity of thought. Most of all, though, do not include any detail that does not have some real or potential significance that you can actually specify.

62. Writing for the reader

In the paper entitled 'The science of scientific writing' that appeared when this guide was in the final stages of preparation, two specialists in linguistics, Gopen & Swan (1990), argued that writing problems such as those described above commonly arise because scientists do not understand their readers' tendencies, needs, and expectations. Gopen & Swan pointed out that readers do not just read; they interpret—and their interpretations depend strongly on the way the information is presented. In the arts, being able to write material that is open to many interpretations is regarded as a talent (Shakespeare was an expert); and to a degree at least, the same is true in science. Your observations and data can mean one thing to you but may inspire very different ideas among your readers, depending on their knowledge and experience. But presumably you want your readers to at least appreciate your perspective, so a reasonable objective is to try to maximize the possibility that they will see and understand it.

In their presentation, Gopen & Swan (1990) illustrated examples of problematical scientific writing and attempted to explain why the problems occur and how to correct or avoid them. They also demonstrated rather nicely that jargon and scientific complexity are not necessarily the root problems (as scientists like to claim), and that poor organization and conceptual gaps in scientific writing frequently require readers to work much harder to understand the argument than should be necessary. And ultimately, they came to the same

conclusion as we do—in their words: 'In real and important ways, the structure of the prose [is] the structure of the scientific argument. Improving either one will improve the other.' The following is a summary of their recommendations (in our words).

A first Gopen & Swan observation is that, in constructing sentences, scientists frequently insert lengthy segments of text (such as participial phrases, subordinate clauses, and other parenthetical statements) between the grammatical subject and its verb(s). The problem with this practice is that readers not only interpret the intervening material as being subordinate in importance, they also find it a nuisance—because they are actively seeking the verb in order to determine where the sentence is going. The associated recommendation is simple: *Minimize the separation of the grammatical subject and its verb(s).*

A second recommendation is more obscure: Articulate the action of sentences through their verbs. But in practical terms, it essentially boils down to: *Make minimal use of the verb 'to be', particularly the forms 'is' and 'are'.* As a linking verb (see footnote 3), 'to be' expresses no action, and a common characteristic of paragraphs that seem to lack direction is that their verbs read '. . . is . . . is . . . are . . . is . . . are . . .'. The effect is that, even though the information may be important and grammatically correct, it can still seem uncoordinated. Try, therefore, to use verbs that will convey a sense of direction and lead readers from one sentence to the next.

The other recommendations by Gopen & Swan (1990) involve what they called 'units of discourse'—defined as blocks of text with a beginning and an end. The most common units of discourse are sentences and paragraphs, but they can also be larger sections of a manuscript. Whatever their length, though, they should make just a single point or serve just a single function. (Thus, a sentence should express only one thought; a paragraph should develop only one idea; new data should not appear in a section entitled discussion; and new discussion should not appear in a summary of conclusions.) A general recommendation, then, is: *Establish the point or purpose of each unit of discourse, and then stick to it.*

Gopen & Swan contended, however, that the dominant problems in today's scientific writing pertain to the sequence in which information is presented within units of discourse. They noted that readers tend to concentrate most on the beginnings and endings of these units—as in paragraphs, where the first and last sentences attract the most attention; or in the manuscript as a whole, where the introduction explains the objectives, and the conclusions give the findings—and they suggested three guidelines for their formulation:

> (1) The start of a unit of discourse should generally define the topic of discussion. Thus, in a paragraph, the first sentence should usually be the topic sentence; in a sentence, the subject should usually be up front.
>
> (2) The start of a unit of discourse should generally also provide both 'linkage' and 'context'. Linkage connects the topic of discussion to what has been said previously; context relates it to what is to come. Together, they provide the continuity of thought that readers need (and expect) to help them absorb information or follow an argument. In paragraphs, as explained in section 59, the topic sentence might give an overview that is then elaborated in the ensuing text. In sentences, continuity can be established through transition words, or by the repetition of key words and phrases from earlier text—or it might even be effected simply through the use of the definite article. There is a big difference, for example, between '*a* dense rock' and '*the* dense rock'. The first generally implies a new reference, whereas the second indicates that the rock has already been introduced or mentioned (hence, the continuity).
>
> (3) The last part of a unit of discourse should generally contain (and emphasize) the most important observations or arguments. Readers tend to expect this arrangement, so if it is not fulfilled, they may miss critical points or make wrong inferences about what is important.

According to Gopen & Swan, scientists often present important information in the first parts of units of discourse, before establishing its context. The information then comes to the reader 'from out of the blue', so it tends to be confusing and can even appear irrelevant, rather than important.

63. Word processors; the rush to submit; and lack of review

For those of us who were doing scientific writing when there were only mechanical typewriters, word processors seem like a godsend—we marvel at them and think how different our lives might have been if they had been available when we were young. In those old days, the threat of the physical effort of having to retype something if you did not get it right the first time was enough in itself to cause writer's block. Even with electric typewriters, the marks of erasures, whiteout, and cutting-and-pasting were constant reminders to write carefully; and the look in your typist's eye told you that three drafts were one too many. Nowadays, you can insert, delete, transfer, and change text with abandon. There are programs to check spelling, to look up words in a thesaurus, even to scrutinize the grammatical structure of your manuscript and tell you whether it is 'interesting'. Then, with the push of a button, you can produce absolutely clean copy, even though you are the world's worst typist.

Thus, given that almost all authors now use word processors, or can call on typists who do, one would think that scientific writing should have improved dramatically in recent years. Our impression, however, is that it has become seriously worse, and others (including several other *Journal of Petrology* editors) support this view. In a letter to one of us written in his editorial capacity with *Geochimica et Cosmochimica Acta*, Dr. S. R. Taylor of the Australian National University remarked that he had noticed 'an increasing tendency for ill-digested papers to be submitted'. [See also Sylvester & Costa (1989).] And in a similar letter based on his experiences both as a teacher and as the editor of the *Journal of Volcanology and Geothermal Research*, Dr. A. R. McBirney deplored the standards of English among recent university students. We are willing ourselves to excuse authors for whom English is not a principal language, and our sympathies lie strongly with young and inexperienced authors, but our author list for poorly written manuscripts goes far beyond them.

One would hope that this writing problem is not just a matter of clean copy—that authors delude themselves into thinking that, because their manuscript looks good, it must be well written. But we sometimes wonder. As one reviewer remarked: 'This paper looked great until I started to read it!' A couple of authors have as much as admitted to submitting manuscripts that they knew were not properly prepared, so whether they realized it or not, they were looking for reviewers and editors to do their work for them—a point on which Dr. Taylor also remarked. A poorly written manuscript is a major imposition on other people, and you cannot assume that you are busier (or more important) than everybody else!

With young authors, there is understandably the matter of being short on writing skills. But often it seems that the real problem is one of (a) they are unaware of their deficiency, (b) they are overly sensitive about it, or (c) they do not realize how much writing affects the review process. The evidence here is that the authors usually give no indication (notably, by acknowledgements) that their manuscripts have ever been looked at by anyone but themselves—even, we suspect in some cases, nominal co-authors. We sometimes have the feeling that, because of (b), they would rather have their work criticized by an unknown reviewer or editor than by a friend. But in most cases, the problem is probably a combination of (a) and (c). The authors are anxious to submit their manuscripts and do not realize that, if a couple of rounds of revision are required, the review process will take not just a couple of months but may well stretch into a second year, with the printing of the paper still to come.

But there is also another possibility, a rather sad one. Perhaps there is no one these young authors can turn to for help.

64. The writing process

Most books on technical writing propose a series of steps such as the following for preparing a manuscript; (a) define the objective; (b) do the research; (c) organize the data; (d) write an outline; (e) write the first draft; (f) revise; (g) get reviews by others; (h) revise again; (i) 'let it cool'—that is, get away from the manuscript for a while to refresh your outlook; and (j) revise again. A common contention too is that, if you make a sufficiently detailed outline, a first draft is easy to write.

Although we basically recommend this scheme, our criticisms are that, for long manuscripts at least, it grossly understates the difficulties of the first draft, and it considerably overstates the value of outlining. In our experience, first drafts are never easy, and outlines are no panacea. The reason, we have come to realize, is that in scientific studies (as opposed perhaps to technical evaluations), the writing is so much a part of the research. As we noted earlier, the writing process commonly brings to light important observations and ideas, and in this way it can greatly influence—and even define—the focus and scope of the manuscript. The present document is a case in point; it began as a modest list but became increasingly complex as we thought and wrote about the problems involved.

Another reason we downplay outlining is that, with word processors, the concept of a 'first draft' can be almost meaningless. One can now correct, revise, and reorganize text so easily while writing it that, by the time the manuscript is completed, some parts may literally have been through a dozen drafts.

The best approach to manuscript preparation, we think, is to treat as an analogue counterpart to the main research effort. One of our colleagues claims to be able to develop his papers completely in his head before he begins writing, and prolific authors do seem to have exceptional skills in this regard. For most of us, though, many of our ideas (and even some of our observations) are often still only rather vague perceptions when we start out, and most of the work of writing is essentially a process of turning these perceptions into well-formulated thoughts, and organizing them into a sensible linear sequence of words. This work is difficult (perhaps 'extremely' so), but it also has a certain appeal because it is creative. (After all, many people *want* to write.) Approaching the writing as a research effort is also a recognition of the possibility that significant discoveries might arise from it. By comparison, trying to set up and follow a comprehensive, detailed outline for a large manuscript is mechanical and stifling—and, for most of us, unrealistic.

As indicated in section 61, our impression is that many authors are not using their word processors effectively. In particular (although obviously we cannot be sure), it seems to us that, in addition to not being sufficiently knowledgeable of the various rules and techniques of writing that we have tried to describe above—and to not seeking enough reviews—these authors are not doing enough *revision and rewriting*.[6] It is in these respects, of course, that word processors have their greatest strength; therefore, we attempt below to describe what we think is a reasonable sequence of steps to follow in writing a petrological manuscript with a word processor. We do this with some reluctance, because we appreciate that writing is an individualistic process and, hence, that what we describe may not work for you. But our hope is that most authors with problems will find at least a few of our suggestions helpful. We apologize too for describing the procedure in terms of steps for *you* to follow, but that seems the most effective approach in terms of our objective.

[6] In *Suggestions to Authors* (6th edn.), Bishop *et al.* (1978) quoted 'one eminent jurist' as saying that 'there is no such thing as "good writing"; there is only good rewriting'.

On the practical side, of course, you should have a word processor. And if you cannot type, learn—the faster, the better; but hunting and pecking is better than nothing. We will assume that most of the collecting and tabulation of data are completed. The steps are then as follows:

(1) Prepare as many of your diagrams as possible. Our experience is that our most important thinking about our research is usually done at this stage. Arrange the diagrams in sequence, and write captions (if only in preliminary form). Add tentative captions for any additional figures that you might anticipate.

(2) Using the caption list as principal control, type into your manuscript file a rough outline (akin to those suggested in section 50).

(3) Begin writing, perhaps by typing directly into the outline. Start in whatever section seems easiest—because it is probably what you have sorted out best in your mind—and continue on that basis. For a short manuscript, you may be able to start with the introduction and work directly through to the conclusions—and if you can do the same with a long one, more power to you (but you do not need to be reading this guide). As noted in section 51, our experience is that abstracts and introductions are best left until the end, when you know what the manuscript actually says. In the writing in general, the most effective approach seems to be to work in blocks of text small enough that they can mostly be organized in one's head. Before you start each, you may want to scribble a few notes as an outline.

(4) During this first stage of composition, use simple declarative sentences as much as possible, and try to write quickly and keep the flow going. The objective is to record a succession of thoughts that is as continuous and coherent as possible. And try also, both in your attitude and your writing, to capture some of the excitement that you had probably experienced at times when you were collecting data. Do not gush, though; what you want is more a matter of tone than statement.

(5) When you have produced a convenient block of text, back up and start revising. Much of what you have written may seem rather rough and disjointed, but do not try to fix it all at once. The best wording may ultimately depend on what you say in some later section that is still to be written. Concentrate on the obvious and necessary improvements first—correct spelling; complete, sort, and resequence sentences, and smooth them if they need it badly. Separate paragraphs on the basis of topic sentences. Through all stages, of course, but especially this one, be especially careful about scientific accuracy. The best way to avoid scientific errors is to keep them out from the start. Add more text, and repeat the above, as it suits you.

(6) When you have solved the more prominent problems in a sizeable block of text by way of the monitor, make a printout, and revise it by hand. Our experience is that working on hard copy is *extremely* important, because things never look the same as on the monitor. The writing process is so engrossing that you tend to overlook the obvious, but hard copy distances you from it enough to give you an overview from which you may see any number of shortcomings that you had missed, from typing errors to major organizational problems. Here again, check paragraph topic sentences and key words. If you leave this job until later, it will become too big, and you won't do it.

(7) For a long manuscript, repeat steps (4), (5), and (6) continuously, perhaps in a daily routine in which you type new material in the morning when you are fresh, edit it in the afternoon, and mark up printout in the evening. By mixing these steps over several sections, you are always up to date on what you have done at the same time as you are thinking ahead to where you are going. Thus, you do not become locked in on any one section before you start the next, and you stay flexible enough to make adjustments. Furthermore, you are always doing something, so you have a sense of progress that helps you avoid writer's block.

(8) When you come to the end of a section, try to organize mentally what you want to say in the next, then start again to write as quickly as possible.

(9) As part of this routine, constantly look for ways to shorten and eliminate sentences; and continually discard irrelevant material. If you have any doubts whatsoever about the value of something you have written, discard it before you become too attached to it. If you cannot bear to part with it immediately, deposit it under a heading entitled 'Junk' at the end of the file. In a day or two, you will probably delete it without regret.

(10) As your manuscript grows, keep an eye on its overall organization. If you see that some substantially different arrangement is more appropriate, save a file copy of what you have done

for security, then shuffle sections and make whatever repairs are necessary to regain coherence and unity. If you are nearing the end of the manuscript, and its contents seem reasonably set, then write the conclusions, introduction, and abstract.

(11) Along the way, during moments when other inspiration fails, do the more mechanical things, such as compiling the reference list and final tables.

(12) When all your text is down on paper, read it through in its entirety, looking for any and all errors in both the science and the exposition. For the writing, concentrate particularly on the coherence and unity of your arguments and the flow of words. Make all the corrections you can; then print a clean copy, and start again. And continue this repetition until you cannot find anything more. Now you need someone else's view.

(13) Give your manuscript to as many people as you can find who are willing to review it. There is nothing more helpful—and commonly, nothing more difficult to obtain—than thoughtful, constructive criticism. Value it, and consider all suggestions carefully.

(14) After you have dealt with these revisions, set the manuscript aside for a few weeks and let it cool. When you come back to it, you might start off reading it *out loud*. Whenever you see an error, stumble on your words, or lose your train of thought even a little bit, mark the place. When done, go back to the word processor and make repairs. If your reviewers were not complimentary (and try to read between the lines of their comments, because they may not have been as rude as they should have been) then probably you should seek more reviews. Only when you have exhausted all your own critics should you consider submitting the manuscript to a journal.

(15) The comments of the journal reviewers and editor may often seem irrelevant, but remember, if someone has failed to grasp your meaning, you are at least partly at fault. So try to take the critic's perspective, see what the problem is, and make adjustments. Once again, check the scientific content. You are practically at your last opportunity to make changes and correct errors, because you will not be able to do much on the galley proof. You have to anticipate that, when the paper is finally printed, the first thing you will see will be mistakes, because the printing distances you another step from the writing process.

Again, the point to appreciate from the above, even if you do not follow the steps in any detail, is how much *revision and rewriting* are necessary to get a good product. Two or three drafts are rarely sufficient.

65. Scientific objectivity: seeing and describing

Although this guide is essentially concerned with exposition, matters of scientific content cannot be ignored completely. There is a well-known aphorism that is often applied to geologists but no doubt relates to all fields of human interest and endeavor:

> We only see what we are looking for.

Apropos this document, we would add a second:

> We only describe what we think we understand.

Both are natural failings, and in a way, both are lifesavers for geologists. Rocks do not change much on a human time-scale, so if we saw everything and described it all on the first time round, we would soon be out of business. But in a profession in which we pride ourselves on our abilities to observe, both pronouncements are rather deflating.

There are some fascinating apparent examples of these two kinds of malfeasance in the literature—and we are guilty of some ourselves that we don't find so interesting. But we have backed off from describing any because, as a reviewer pointed out, what may now appear as an example of the second might actually have been a case of the first, which is a less serious offense. The message remains, though. In your writing, try to keep an open mind. And do not ignore observations or phenomena in your descriptions just because you cannot explain them. In particular, describe observations that do *not* fit your ideas just as carefully as those that do.

66. Teaching geological writing

Through the above discussions, you will have recognized an undertone that petrologists (and probably Earth scientists in general) are not being—and for some time now, have not been—properly taught how to write, at least in North America. In our own case, we have clearly been slow learners. This guide is no Derridean treatment of writing, but we are almost as appalled as we are pleased by how much we have learned in preparing it.

It is probably fair to say that writing problems are generally deeply rooted in a person's disposition and education. In the case of geologists, most of us probably do not read enough (reading being a primary key to good writing). For the more ancient of us, this problem is in part a matter of not having adequate libraries when we were young; for today's generation, the problem is undoubtedly due in part to distractions such as television, video games, and computers. The geologist's attraction to an outdoor life may itself be a reflection of a critical personality trait. With respect to grammar, we cannot ourselves remember when we last were taught it for English. Our recollection is that we came to understand more by studying other languages.

We are told that most universities now offer more writing courses for scientists than were available when we were students. But it seems likely too that a fundamental problem that was obvious then still exists—namely, that many geology students are actually trying to get away from humanity courses *because they require writing*. If these students see a way to avoid writing courses, most of them will take it.

We understand too that many English departments protest that they are doing as much as they can to teach writing to scientists, but that they cannot teach the writing that is idiosyncratic to each discipline. And they further complain that science professors characteristically refuse to help out, on the grounds that they are too busy teaching the 'content' of their disciplines.

We feel uncomfortable with an apparent implication of this last argument—to the effect that writing does not rate with 'content'—because as scientists specializing in research, writing is such a critical part of our work. We too would be reluctant to teach writing in collaboration with an English department, but for two reasons that seem much more to the point. First, we would not want to do the marking. And second (the real answer), despite our experience, including the preparation of this guide, we would anticipate great difficulty in working within the format of an English course. Our detailed knowledge of writing and our skill at doing it are embarrassingly weak when compared with those of specialists in English.

But neither does teaching geological writing through an English department seem to us to be the appropriate approach. In terms of the complaints we have been voicing in this guide, our impression is that the practical solution is for petrology professors in particular, but better, for geology departments in general, to treat writing as an essential part of their courses—because in fact, that is what it is. Writing is very much a matter of thinking, and that, after all, is what all university courses are supposed to be about. The question is, how to do it.

Because we are not teachers (or, at least, have not been for a long time), our recommendations are probably not particularly original, and they may even have been tried and proved impractical. Our fond hope, of course, is that this guide will be a significant help. It touches on virtually all aspects of grammar and composition that seem important to geological manuscripts, and it gives, we believe, enough information to be useful as a starting point for developing examples and exercises. Our list of pet 'peeves' about terms in petrology could easily be expanded to encompass other fields of geology.

The obvious way to minimize the teaching job, including the marking problem, is to spread it around. We have been told of individual attempts by geology professors to teach writing that were valiant but doomed because the task was too much for one person. The effort has to be cooperative so that it is modest for everyone. Essentially, we would envisage most courses for seniors and new graduates having perhaps one lecture on writing plus at least one assignment in which consideration was given to composition as well as 'content'. At first, emphasis might be placed on sentence structure and techniques of paragraph construction involving the use of topic sentences, key words, transition words, and parallel structures. Emphasis might also be placed on understanding and avoiding the passive voice, dangling participles, the phantom 'it', and blatant anthropomorphism. Later, as the students' scientific knowledge expanded, more attention could be given to manuscript organization, details of terminology, subordination and sentence sequencing, and the requirements of journal format and style. In all this process, we see two points as being especially critical. The first is that writing should be treated as a part of regular assignments; and the second is that professors should actually *teach* some writing. Giving this guide to students and saying, 'Read this', may solve a few writing problems, but for there to be major, sustained improvements throughout our science, professors have to demonstrate that they consider writing to be a serious matter by actively participating in the learning process.

Matters of journal style and format

The closer you can follow the journal format, of course, the less work someone else has to do on your manuscript. Unless otherwise noted, the instructions below pertain to *Journal of Petrology* conventions. If your printer does not italicize, then underline. The equivalent of bold face is 'squiggly underlining'.

67. Title, authorship, and headings

Put the title and the names and addresses of the author(s) in the format of the journal—e.g., as in the title information of this guide. We encourage the use of principal given names, rather than just initials, because they can be useful to readers, and it is particularly important that women be recognized.

With regard to headings, three ranks should be ample, and two (or even one) may suffice. Their format should be as follows:

FIRST RANK; UPPER-CASE LETTERS, CENTERED ON THE PAGE

Second rank: lower-case letters, centered and italicized

Third rank: lower-case letters, at left margin and italicized

Note that in the second- and third-rank headings, only the initial word and proper nouns should be capitalized. In general, headings should not be part of the text; it should read as though they do not exist (but try not to repeat them).

Headings for the Abstract, Acknowledgements, References, Tables, and Appendices should be treated as first-rank headings.

68. British vs. American spelling

Journal of Petrology accepts either British or American spelling; just be consistent. Some common differences: the British use aluminium, amygdale, analyse, centre, colour, dyke, favour, metre, orientate, Palaeozoic, programme (except in 'computer program'), and sulphur; Americans use aluminum, amygdule, analyze, center, color, dike, favor, meter,

orient, Paleozoic, program, and sulfur. See section 9 for differences of hyphenation. *Journal of Petrology* uses 'crystallize', not 'crystallise'.

69. Common abbreviations and symbols

Note the italics and periods.

wt. %	mol. %	vol. %
ppm (parts per million)	μm (micron), mm, cm, km	g, kg
s, min, h, y	my (millions of years, as in a time interval or age difference)	
ka, Ma, Ga (thousands, millions, billions of years *ago or before present*, as in an age or date)		
atm	b, kb, mb	Pa (Pascals), MPa, GPa
g/cm^3 (preferable to $g\ cm^{-3}$)	poise (plural form)	Fe^{2+}, Fe^{3+} (not Fe^{+2}, Fe^{+3})
REE (rare earth element)	LREE (light . . .)	HREE (heavy . . .)
°C (degrees Celsius)	K (Kelvin: 400 K)	(400–500 °C, *not* 400°–500 °C)
N55 °W, dip 50 °SW	(But use 'northwest', not 'NW.')	lat. 52 °40′N, long. 120 °30′W
i.e., (that is; note comma)	e.g., (for example; note comma)	
ca. (approximately)	cf. (confer or compare)	*et al.* (for three or more authors; note period)
viz. (specifically)	vs. (versus)	

Abbreviations such as km, kg, my, Ma, kb, and REE refer to the plural as well as the singular—as in 200 km or 1 km, or 20 kb or 1 b. Most abbreviations are plain (Roman) text; some Greek and Latin abbreviations are italicized. Note that 'cf.' does *not* mean 'see'.

70. Abbreviations, symbols, numbers, and formulae at the start of sentences

Do not start sentences with abbreviations, symbols, numbers (unless written out in full), or formulae:

Gallium increases in concentration from basalt to andesite. (Rather than 'Ga increases. . .)
The Al_2O_3 content of the liquid decreases as plagioclase crystallizes. (rather than 'Al_2O_3 decreases in the liquid as. . .)
Fifty-five samples were analysed. (*Not* '55 samples were analysed'.)

A major example in the *Journal of Petrology* is:

Use 'Figure 1' *at the start of a sentence, but* 'Fig. 1' *everywhere else.*

But note that other journals have different practices. A common alternative is to use '(Fig. 1)' for a reference in parentheses, but 'Figure 1' everywhere else.

71. Equations and notation

An equation that forms the end of a sentence should be followed by a period. Punctuation at the end of the text preceding the equation should be included only if it would be needed for an equation not displayed. If you have many equations identify them in sequence by numbers in parentheses just inside the right margin. Define all symbols. Those for variables and constants should be italicized; operators, trigonometric functions, and two-letter symbols derived from personal names (e.g., Re, for Reynolds number) should be in plain (Roman) type; vectors and tensors, in bold face. If you use many symbols, put them in a table.

72. Numerals

Use zero before the decimal point in quantities less than unity, as in 0·515. Numbers comprising five or more digits should be written in groups of three, separated by thin spaces (not commas).

73. Parentheses and brackets

Close all parentheses and brackets (as in a computer program): e.g., (a), (b), (c), or [1], [2], [3].

74. References

Note the indentation, punctuation, ampersands, italics, bold face, *ibid.*, and page numbering in the following examples.

(1) References to journal articles:

Bailey, D. K., 1969. The stability of acmite in the presence of H_2O. *Am. J. Sci.* **267A**, 1–16.
Bowen, N. L., & Schairer, J. F., 1935. The system MgO–FeO–SiO_2. *Ibid.* **29**, 151–217.
Buddington, A. F., & Lindsley, D. H., 1964. Iron–titanium oxide minerals and synthetic equivalents. *J. Petrology* **5**, 310–57.

(2) Reference to a book:

Wager, L. R., & Brown, G. M., 1968. *Layered Igneous Rocks.* Edinburgh: Oliver & Boyd, 588 pp.

(3) Reference to a chapter in an edited book:

Goldsmith, J. R., 1959. Some aspects of the geochemistry of carbonates. In: Abelson, P. H. (ed.) *Researches in Geochemistry.* New York: John Wiley, 336–58.

(4) Text citations:

Give page numbers where they might be helpful, particularly for books. Multiple references should be listed by year, alphabetically within a year.

According to Wager & Brown (1967, pp. 26–7), pigeonite was cumulus in MZ but is now inverted.
The pressure limit of the cylinder is 20 kbar (Click & Clack, 1989).
The terrane was first uplifted in the Proterozoic (Smith, 1933; Jones *et al.*, 1945; Brown, 1987; Zen, 1987).
The Jones & Smith (1957) technique was used. [Rather than 'Jones & Smith's (1957) technique was used.']

As much as possible, put parenthetical reference citations at the ends of sentences, or between principal clauses, so as not to break up the continuity of thought.

(5) Frequency and accuracy:

It is important to give credit to previous authors, but references require page space, so keep the number of citations to a reasonable minimum. For general background, refer to review articles if possible rather than numerous original sources, but cite truly keystone articles. Be sure too that your citations are genuine as well as accurate in format. Give authors their full due (in a positive sense), and neither underplay nor exaggerate the support of their contributions with respect to your own argument. In particular, do not cite their work in ways that might imply support for your views if, in fact, their findings or conclusions were opposed. The popular statement, 'So & So (1989) *showed* . . .' is frequently an exaggeration. Usually, So & So only suggested, implied, or provided some limited evidence. And remember too that the objective of original research is to build on other peoples' works, including their mistakes, not to prove that they were wrong.

75. Figures

(1) Figures should be numbered in the order in which they are introduced in the text—or vice versa. It is helpful to indicate approximately where you would like the figure to be placed—e.g., by a note like the following:

- - - - - -
Figure 3 near here.
- - - - - -

(2) Every map should have a graphical (bar) scale and a north arrow, or it should show latitudes and longitudes. Even with lats and longs, a bar scale is often helpful. Explain all patterns and symbols, if possible *in a legend on the map* (as opposed to a description in the caption), and define all abbreviations.

(3) Every graph should show the units of the parameters being plotted—for example:

K_2O, wt.%; Temperature, °C; Pressure, kbar; Stratigraphic height, m.

Avoid graphs that are 'plots of something against nothing' in which one axis simply represents the samples arranged in some arbitrary, no doubt convenient, but obviously subjective order. Histograms (where sample frequency is the second variable) are more appropriate.

(4) If plot points on graphs are coded symbols, they should be explained in one of the following ways:

Best: (a) Labels on the diagram with pointers to specific points or to line envelopes (solid, dashed, dotted) around groups of points.
(b) A graphical legend on the diagram. (Locate in some open area; frame if appropriate.)
(c) In the caption immediately below the graph. (Keep the symbols simple so that they can be easily described, or so the typesetter can reproduce them.)
Worst: (d) In the caption of some earlier figure.

If possible, avoid the last two methods, especially the last. If readers have to switch repeatedly from graph to caption, they will probably miss important features of your diagrams; *if they also have to go back and forth several pages, they are not likely to take in much at all.*

(5) Configure your diagrams so that they will fit the journal page with critical parts at maximum possible size. Do not have words extending out unnecessarily at the edges, so that extra reduction is required to accommodate them. If several diagrams are combined as one figure, arrange them for best effect yourself; you can adjust their relative sizes and shapes as no one else can. Be sure that all lettering is large enough to be legible when the figure is on the journal page. A sure test is to reduce the diagrams to the appropriate size in a copy machine.

(6) If a figure has several major parts, label them alphabetically. We recommend upper-case letters, but whatever you use, reference them in the caption and text by the same denotation—that is, if you have parts 'A' and 'B' in Fig. 3, reference them as either 'Fig. 3A' or 'Fig. 3, B'—*not* as 'Fig. 3a' or 'Fig. 3(b)'.

(7) The figure captions should be typed on a separate page or pages, as nearly as possible in the journal format (note the different capitals in 'FIG.' if your printer will make them):

FIG. 1. Generalized geological map of the Beartooth Mountains, Montana, showing the location of the Stillwater Complex.
FIG. 2. Stratigraphic sections of the Ultramafic Series of the Stillwater Complex: (A) Boulder River region; (B) Mountain View region.
FIG. 3. Plots of whole-rock concentrations of MgO, NiO, and Cr_2O_3 against stratigraphic height through the Troctolite–Anorthosite Zone I.

(8) Photographs obviously should be as sharp as possible and should show a scale. In times past, *Journal of Petrology* presented photographs as 'Plates' rather than figures, but the practice has been terminated.

76. Tables

Compile tables on separate pages, following the format of similar tables in previous issues of the journal. Headings giving table numbers should be first rank; table titles should be centered beneath them. Keep the tables as compact as possible, and shape them to make effective use of the journal page size and shape. Define units for all variables, and for data on

rocks and minerals, provide information sufficient to locate the sample sites, preferably on some map.

Frequently authors have collected much more data than can be published in journals, in which case only selections should be presented. A data repository is currently being managed for the *Journal of Petrology* by Dr. M. J. Le Bas at The University of Leicester, and presumably it will be maintained indefinitely, so authors are encouraged to provide complete data sets for it.

FINALE

77. Perfectionism

All the above comments are concerned with making your manuscript better, both in itself and in terms of minimizing the work that other people have to do to turn it into a published paper. But there is another side to the coin—trying to make it too good. At some point, you have to stop revising and send the manuscript to a journal. Usually the deciding factor is time—you have to move on to another job.

But remember too, perfection is not the goal. A useful way of looking at science (and life in general) is that it is an ever-continuing conversation or dialogue. If the current topic interests you, and you want to participate, then you have to insert your voice into it. You say what you have in mind as well as you can and hope that your observations and insights will be appreciated and have effect. If they are good, they may; if they are not, they probably won't, no matter how well they are said. But if you hold back because you are trying to get your words exactly right, the topic may change (or you may have to leave) and what you had in mind will never be heard—or someone else will say it.

And there is also an edge to the coin. Reviewers and editors should not demand perfection either. But remember, editors do have some investment in your paper (not much, mind you, but some!), and being editors, they have probably seen more standards for comparison than you. In some obscure way also, they have your interests at heart; they are doing their job because they want to see your work published.

78. The power of words

'The journey is one of choices, judgement, of logic; . . . words . . . become instruments of power.'

In this guide, we have tried to show that manuscript preparation is indeed such a journey. We hope our recommendations will eliminate many wrong choices and will help make some of the judgements a little easier for authors so that they can concentrate more on the problems of logic.

As for the power of words, what petrologists or geologists seem generally to think of as the 'science' in their manuscripts essentially comprises the observations and insights that have arisen from their work. The purpose of reviewers and editors is to try, on the basis of their knowledge and experience, first, to ensure that the science is accurate and reasonable, and second, to see that the presentation is intelligible. The distinction is not always so clear, however. In our experience at least, manuscripts tend to form a two-end-member system that we sometimes describe as having good science at one end and poor writing at the other, but that is almost as well portrayed as having good writing at one end and weak science at the other. The best scientific contributions typically are clearly written, and in all cases, when the writing is improved through revisions, the science invariably benefits. The strongest observation, though, is that the most difficult manuscripts to deal with (by far) are those in which you can scarcely focus on the science in terms of anything but writing problems. The well-written manuscript is, by contrast, the proverbial breath of spring. You quickly

recognize that the authors are saying what they mean, and mean what they say, and you sense that even if the science is problematical, it is still likely to be interesting. The writing problems never are.

With that, our last recommendation:

79. Do as we say, not as we do.

Nostra culpa!

ACKNOWLEDGEMENTS

We acknowledge again—this time with thanks—the use of Hatten Yoder's list of recommendations as seed. Hat also reviewed the manuscript, and he should probably be a co-author, but we feel we can credit him more this way for what is good, while sparing him from identity with parts that he may not approve of (including this sentence). Hat was one of the original editors of the *Journal of Petrology*, and over the years he has reviewed an enormous number of manuscripts. His generosity in this work, particularly in his promptness and thoroughness, is most remarkable. We are personally indebted to him in all of his roles—as Director, critic, teacher, and friend.

Our present Director, Charles Prewitt, also reviewed the manuscript, and his comments were valued because of his experience as both a professor and an editor.

We are especially pleased to thank Felix Chayes for many detailed, thoughtful comments. Felix is one of the few Earth scientists we know who writes with an admirable style that is distinctively his own. In particular, we have always enjoyed his ability to develop scientific arguments in ways that are (deliberately) humorous.

Other readers who made useful comments were Gray Bebout, Marilyn Fogel, Bjorn Mysen, Craig Schifferies, Dave Virgo, and Jinmin Zhang at the Geophysical Laboratory, Dodie James at the University of Edinburgh, and several of the present and past editors of the *Journal of Petrology*.

Finally—and not least—we thank the authors whose writing inspired this guide. We have ultimately benefited from the journey of their manuscripts; we hope the journey of ours will be helpful to them.

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APPENDIX 1

Basis, production, and responsibilities

As indicated in the text, 'we' means T.N.I. and D.R., loosely in our roles as editors. The contributions of L.M.I. as consultant are explained below.

The one of us who wrote the guide (T.N.I.) is essentially responsible for it—particularly the parts that might prove incorrect or offensive. What might be called my research has involved a lifelong struggle with words and writing, the review of many manuscripts, the editing of two multi-authored volumes, two 3-year stints as an associate editor with other journals, and 3 years as an editor for *Journal of Petrology*. The first draft of the manuscript involved 5 weeks of intensive writing, and some material was printed out about every other day, so most parts went through at least six hand-marked revisions, and many went through more than a dozen. A total of roughly another 6 weeks were spent on revisions in response to reviews by colleagues and other readers; intervening 'cooling periods' totaled about 7 months. Apropos of a major theme of the guide, I probably came to understand as much about the subject through the writing as from the research. I also admit to shedding considerable responsibility on my co-author, but 'we' worked much better than 'I'—and he was helpful.

The contributions of D.R. were encouragement, suggestions, and criticisms, and particularly his approval and support as an editor.

As consultant, L.M.I. supplied the introductory quotation; did much to clarify our understanding of voice, person, participles, and subordination; encouraged the views expressed with regard to using the first person and not using the passive voice; and recommended the concept of science (and life) as a dialogue.

APPENDIX 2

Principal grammatical terms

Parts of speech: the eight groups or kinds of words—*nouns*, *pronouns*, *adjectives*, *verbs*, *adverbs*, *prepositions*, *conjunctions*, and *interjections*.

Noun: a name, as for a person, animal, place, substance, quality, action, measure.
- *Common noun*: any one of a class of persons, places, or things (*man*, *city*, *book*).
- *Proper noun*: a particular member of a class (*Jack*, *Ottawa*, *Lake Winnipeg*).
- *Collective noun*: a group of persons or objects (*audience*, *pile*).
  Each type of noun can be either *singular* or *plural*. A collective noun is singular when it designates a group acting as a unit. (The group *is* arriving.) And it is plural when the members of the group act independently. (The group *are* writing their notes.)
- *Genders*: *masculine*; *feminine*; *common*, either; *neuter*, neither (inanimate).
  Because of the 'his or her' gender problem, certain nouns that traditionally have been singular are now sometimes treated as collective nouns and used with 'their' (notably *everyone* and *everybody*, as in: Everyone has their own style).

Pronoun: a word used in place of a noun (*he* or *his*).
- *Antecedent of a pronoun*: the noun or pronoun to which a pronoun refers.
  (*John* lost his writing.) 'Antecedent' means 'going before'.
- *Personal pronoun*: refers to the person speaking, the person spoken to, or the person or thing spoken of: *first person* (I, my, mine, me, we, our, ours, us); *second* (you, you, yours); *third* (he, his, him, she, her, hers, it, its, they, their, theirs, them).
- *Interrogative pronoun*: used in asking questions (who, whom, what, which, whose—as in: *who* is that? For *whom* is this?).
- *Demonstrative pronoun*: points out definite persons, places, or things (this, these, that, those).
- *Indefinite pronoun*: does not refer to definite persons, places, or things (all, anybody, each, everyone, few, none, somebody, . . .).
- *Relative pronoun*: joins the clause that it introduces to its own antecedent (who, which, that, what, whoever, . . .—as in: the one *who* is shall be; or, the finger *that* writes moves on).
- *Pronouns as possessive adjectives*: (*her* writing; *their* manuscript, . . .).

Modifier: a word that changes slightly the meaning of another word (adjectives, adverbs, many phrases and clauses).

Adjective: a word that modifies a noun or pronoun.
- *Descriptive adjective*: self-explanatory (*good* writing).
- *Limiting adjective*: indicates quantity (*many* papers).
- *Proper adjective*: made from a capitalized name (*Canadian* books).
- *Demonstrative adjective*: a demonstrative pronoun (this, that, these, those) when coupled with its antecedent (*this* writing; *these* books).
- Adjectival degrees of comparison: *positive*, no comparison implied (*good*); *comparative*, compares two persons or things (*better*); *superlative*, more than two (*best*).

Article: a special kind of adjective: definite (*the*); indefinite (*a*, *an*).

Verb: a word that expresses an action, condition, or state of being (We *write*; it *contains*; I *am*).
- *Complement*: a word or word group that completes the meaning of a verb (object, predicate noun, predicate adjective).
- *Direct object*: a verb complement that receives the action. (He writes *papers*.)
- *Indirect object*: always precedes a direct object; specifies to whom the action is directed or for whom it is performed. (He wrote *Kerri* a letter.)

Verb types: There are three types, but some verbs can be more than one type.
1. *Transitive verb*: takes an object. (She *writes* books.)
2. *Intransitive verb*: does not require an object. (They *write* badly. It *appeared* slowly.)
3. *Linking verb*: does *not* express an action; connects the subject to a predicate noun or predicate adjective (forms of *to be*, *seem*, *appear*, *grew*, *taste*, . . . , as in: He *is* a fool. She *appeared* angry.).

Verb tenses: There are six tenses, and each has a set of passive-voice forms. A *regular* verb (*call*) is used here as an example, but many verbs are *irregular* (including *write*).
- *Simple tenses*: *present* (I, you, we, they *call*; he, she, it *calls*); *past* (*called*); *future* (I, we *shall call*; you, he, she, it, they *will call*).
- *Perfect tenses*: *present* (I, we, you, they *have called*; he, she, it *has called*); past (*had called*), *future* (I, we *shall have called*; you, he, she, it, they *will have called*).
- *Passive simple tenses*: (I *am* called, I *was* called, I *shall be* called, you *are called*, . . .).
- *Passive perfect tenses*: (I *have been* called, I *had been* called, I *shall have been* called, . . .).

Verb moods: forms of a verb that indicate the manner in which the action or state of being is expressed. There are three moods:
- *Indicative mood*: a statement of fact. (He *wrote* the letter.)
- *Imperative mood*: expresses a command or request—always to *you* but seldom explicitly. (*Write to me*.)
- *Subjunctive mood*: expresses a wish, or a condition contrary to fact. (If I *were to write* a book, I would get tenure.)

Adverb: a word (commonly ending with *ly*) that modifies a verb, an adjective, or another adverb (writes *well*; *extremely* good; *exceptionally* well).
- *Interrogative adverb*: introduces a question and modifies the verb (when, where, how—as in: *When* are you writing?).
- *Affirmative adverbs*: gives firmness to a statement; note comma (yes, no, not—as in: *Yes*, I am going. *No*, I am *not* writing.).
- *Adverbs of degree*: indicate how good, how much, how big, . . . (very, rather, too, much, so, . . .—as in: This writing is *rather* dull.).
- Adverbial degrees of comparison: *positive* (writes *poorly*); *comparative* (writes *better*); *superlative* (writes *best*).

Sentence: a word group that expresses a complete thought; it must have a subject and a predicate.

Subject: the part of a sentence that tells what the speaker or writer is talking or writing about.
- *Simple subject*: usually a noun or pronoun. (*He* is writing.)
- *Complete subject*: simple subject plus modifiers. (*The new typist* is writing.)
- *Compound subject*: two or more simple subjects. (*Mike and I* are writing.)

Predicate: the part of a sentence that makes a statement about the subject.
- *Compound predicate*: contains two or more verbs. (She *reads and writes*.)
- *Predicate noun*: a noun that is complement to a linking verb. (She is a *writer*.)
- *Predicate adjective*: an adjective that is complement to a linking verb. (It seems *cheap*, but it is *expensive*.)

Preposition: word that shows relationship between certain words (about, above, across, after, against, along, among, around, at, before, behind, below, beneath, beside, between, beyond, by, down, during, except, for, from, in, inside, into, like, near, of, off, on, since, to, toward, through, under, until, up, upon, with, within, . . .).

Participle: a verb form used as a adjective. (He ran out, *shouting*.)

Phrase: a word group *without* a subject or predicate that is used as a part of speech—i.e., as though it were a single word.
- *Verb phrase*: two or more verb forms used as a single verb (*are writing*; *have been writing*).
- *Prepositional phrase*: combines a preposition and an object. There are two types:
  - *Adverbial phrase*: modifies like an adverb. (He wrote *down every word*.)
  - *Adjective phrase*: modifies like an adjective. (The page *of the book* is torn.)
- *Participial phrase*: a participle with a complement or modifier. (He ran, *shouting for joy*.)

Clause: a word group containing a subject and predicate. There are two types:
Independent (main) clause: can stand alone as a simple sentence. (*She wrote a paper.*)
Dependent (subordinate) clause: cannot stand alone because it does not express a complete thought. Three types are identified by their modifying functions:
Adverbial clause: modifies a verb. (He wrote *while he was away.*)
Adjective clause: two types:
Restrictive: identifies the word it modifies. (The man *who wrote* was right.)
Nonrestrictive: gives added information. (Mike, *who is still here*, is writing.)
Noun clause: could be used as a noun. (We learned *that they are writers.*)
Conjunction: a word that connects words or word groups (*and, or, but, . . .*).
Coordinating conjunction: joins words, phrases, or clauses of equal rank or identical function, as in compound subjects, compound predicates, or compound sentences (*and, or, but, nor, for, yet,* and *so*).
Subordinating conjunction: connects—and *produces*—sentence elements of different rank or weight; commonly joins dependent clauses to independent clauses (*after, although, as, because, before, if, hence, since, so, than, that, though, thus, unless, where, whereas, . . .*).
Correlative conjunctions: used in pairs (*both . . . and; either . . . or; neither . . . nor; if . . . then; not only . . . but also; . . .*).
Punctuating conjunction: comma or semicolon plus a conjunction (*. . . , and . . . ; or . . .*).
Sentence types: two systems of classification:
1. *Declarative sentence*: makes a statement.
Interrogative sentence: asks a question (?).
Imperative sentence: a command or request.
Exclamatory sentence: expresses strong feeling (!).
2. *Simple sentence*: has one subject and one predicate, either or both of which can be compound. (*He reads. He and she write. She reads and writes.*)
Compound sentence: has two or more independent (main) clauses (shown in italics in the examples, where the 'and' is a coordinating conjunction, and the semicolon is a punctuating conjunction). (*She reads,* and *he writes. They read; I write.*)
Complex sentence: has one independent clause, and one or more dependent (subordinate) clauses (shown in plain text in the examples, where 'when', 'while', and 'even though' are subordinating conjunctions). (*He reads* when she writes. While he was writing, *the children were outside,* even though it was raining.)
Compound–complex sentence: has two or more independent clauses, and one or more dependent clauses. In the following example, 'while' is a subordinating conjunction, 'and' is a coordinating conjunction. (While he was reading, *she was writing,* and *the children were playing.*)
Comma fault: incorrect use of a comma as the sole connection between two independent clauses. (*He writes, she reads.*)
Run-on sentence: incorrect sentence in which two or more independent clauses are run together without any connecting word or mark of punctuation between them. (*They read he writes she types.*)
Gerund: a verb form used as a noun. (*Writing* is a skill.)
Infinitive: a verb form, usually preceded by *to*, used as:
a noun. (*To write* is difficult.)
an adjective. (The desire *to write* is low.)
an adverb. (She started *to write.*)
The *to* is omitted only to avoid awkward expressions. (He dares not (*to*) *write.*) In a *split infinitive*, the *to* is separated from the verb. (She started *to* carefully *write.*) Such practice is not generally recommended. (Better: She started to write carefully.)
Interjection: a word or word group expressing strong feeling or sudden emotion. (*Finished!*)

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