Radio Description of Geologic Features:
Examples and Conclusions

by

Ivo Lucchitta, John W. M'Gonigle
and David Schleicher

May 1969

Prepared under NASA Contract No. T-65253G

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.
Radio Description of Geologic Features:
Examples and Conclusions*

By Ivo Lucchitta, John W. M'Gonigle and David Schleicher

Introduction

This report presents three examples of radio description of geologic features. The descriptions and their annotations reflect ideas derived from a field test held in the Rainbow Gardens area, near Las Vegas, Nev., in April 1967. The test employed a data-reduction center conceptually similar to that proposed for lunar exploration. The purpose of the test was to study certain aspects of geologic exploration—description, communication, and recording—as adapted for use with the data center. In the test, a field man (corresponding to the astronaut) radioed geologic descriptions to the data center, where a "communicator" edited them for clarity and completeness, while "recorders" systematically recorded descriptive data and compiled maps and sections.

A basic function of a data center is to analyze incoming geologic data, so as to be able to redirect a continuing geologic traverse to ensure gathering the greatest possible amount of significant information in the time available. If the center is to function efficiently, the data team must be able to promptly assimilate the incoming field data, record them unambiguously, and literally visualize the field relations; otherwise, they cannot really contribute to the field man's efforts. The need for immediate intelligibility of the field data implies a need for systematic description procedures. The discussion of such procedures in the test report** is documented and illustrated by the descriptions in this paper.

*Prepared under NASA Contract No. T-65253G
Transcript

Part A of this paper presents a description taken from the test and a revised, improved description covering the same ground in about the same detail. Both descriptions have explanatory annotations. The field transcript has been "edited" as well, in order to emphasize its ambiguities; many of these are admittedly minor, but they are the very things that make the final assembly of a geologic report so difficult. The editing is by no means complete, and the improved version is by no means perfect; both are merely illustrative. "C," "Rj" and "F" refer to communicator, recorder, and field man, respectively. The field man in this test is an experienced and articulate field geologist. Obviously, it is relatively easy to edit and improve the transcript of a rough field description. The point is that the subject matter of this description is really so routine and so straightforward that a methodical approach and a little practice in systematic description would have largely eliminated the need for editing.

Part B presents an example of what we would consider a "good" description. Though based on the test, it is fictitious, the better to illustrate several points to be made. No responses from the data center are given, since the example focuses on description, rather than on the interplay between field man and data center.

Perhaps the best way to understand the importance of a systematic approach to geologic description is to assume the role of recorder, that is, actually to sketch sections or diagrams from the information given in the descriptions.
Summary and Conclusions

If geologic descriptions are to be radioed to a data center, they should be immediately intelligible; to be intelligible, they must be presented systematically. A description guide has proved to be one means for doing this successfully. The following conclusions were drawn from the field test and were employed in constructing the "improved" and fictitious descriptions.

1) A description guide is a valuable mnemonic aid. Because any such guide is deliberately concise—hence not comprehensive—practice is required for its proficient use.

2) Description should be systematic and should, in general, proceed from the system to the component, the general to the particular, the rule to the exception, the far to the near. This is necessary not only to ensure the satisfactory communication of information, but to encourage the completeness and accuracy of the observation itself, in some cases bringing out details and relations otherwise unseen. Descriptions probably need not be rigidly systematized; certainly, though, an organized presentation aids recording. Because such a procedure is logical, it is relatively easy to learn and use.

3) In general, information should not be given between stops on a traverse because it is confusing and almost impossible to record systematically.

4) For each description, it is important to establish the geologic context against which information can be seen, understood, and
evaluated. Accordingly, the field man should first present a
generalized picture, indicating what information he will give and,
in some cases, why. In general, geologic objectives should be planned
before the traverses, and the data center should remind the field man
of them at each stopping point.

5) The field man should categorize or label information before giving
it; he should, for example, indicate whether the information should go
on a map or on a recording form, or whether it is an incidental note
to appear only on magnetic tape. He should also indicate how detailed
his description will be, thereby preparing the data team for recording
the data in the most appropriate ways. If the field man plans to give
information on a particular subject at a later time, he should say so.

6) Verbal description of geometric relations is difficult. Until an
electromechanical line tracer or similar device becomes available, such
description should be kept to a minimum. Possibly, geometric information
should be handled by conventional mapping, or by annotating Polaroid
photographs in the field; the function of the data center would then be
to compile and coordinate only verbal data.

7) Frequent summarization of data by the data center for the field
man enables the entire team to check the data for errors and to keep
abreast of the compilations.

8) Whenever possible, the field man should describe objects by com­
parison with familiar objects or with objects that were described pre­
viously.

9) Distinctive, characteristic, and important features of any object
should be mentioned even though they may seem "obvious" to the field man.
10) Topographic and photogeologic features should be labeled before the traverses to speed up description.

11) The field man should not waste time verbally describing features that are best portrayed by a photograph, but he should give enough information about each photograph to make its significance clear.
A. ACTUAL DESCRIPTION

Field Transcript

"Editing"

Text

F: OK. I am in the middle part--hold on a minute (pause)--in the middle part of Unit four, at the following coordinates: (pause)
C: That was a little bit "staticky." Let me repeat these coordinates as I got them: five point eight, H point three-eight, over.
F: You're coming in intermittently. Repeat.
C: Your coordinates are as follows: five point eight, H point three-eight, rather H three point eight, over.
F: Yeah, that is correct. There's a broad wash cutting through light and dark bands at that point.
C: Check.
F: You hear me?
C: Yes, go ahead. Can you hear us?
F: You keep getting cut out.
C: OK. (Pause) At this point I am on the west edge of a dark strip that runs across, over.
F: The section below this point is the same as that described earlier, the reddish brown gypsum and shale... beds--ah--make up this bundle. I'll start at the bottom and describe these going up.
C: Give us the point again where you are going to start. Are you going to start from your coordinates?
F: That's correct.
C: Do you want anything—any of the previous
descriptions read to you? Over.

F: No. I'm starting on a new part of the section.

C: OK. Go ahead.

F: I don't know how much new section was below me,
but it all looks the same as what I had been
through before—those reddish brown gyp shales.

C: OK.

F: At this point, the west edge of that dark band,
there is a two-foot bed of siltstone.

C: Go ahead.

F: Fresh color: pale yellowish brown; weathered:
light brown and moderate brown.

C: Just a minute. Are you going to be giving us
a more or less generalized description of
these stratigraphic units?

F: I'm going to break it down into four or five
major little bundles.

C: Amount of detail should have been specified earlier,

This and the following statement give
the context for the description that is to follow.
stratigraphic sequence?

unit?

Are both the quartz (?) and gypsum very fine sand?

Or is there very fine sand of indeterminate composition in addition to quartz and gypsum grains of indeterminate size? What are the proportions of these components?

C: OK.

F: And the whole thing is only forty or fifty feet thick.

C: OK.

F: Distinctive (?) siltstone that I just mentioned is very thin bedded; small-scale cross bedding and ripple marks; contains very fine sand, quartz (?) sand and gypsum grains.

C: OK.

F: Then there's the next unit is (sic) the reddish brown gypsiferous shale.

C: How thick?

F: Ten feet.

F: Very soft and crumbly and does not stand up as a ridge at all.

C: Roger.

F: It's the same as the same part of the unit below.

C: OK.

More precise term would eliminate ambiguity.

Words followed by "(?)" were not unambiguously recoverable from magnetic tape; any such ambiguity should be clarified immediately.

Illustrates possible ambiguity in verbatim transcript; systematic presentation and record-keeping largely eliminate this confusion.

No acknowledgement from C.
<table>
<thead>
<tr>
<th>&quot;Editing&quot;</th>
<th>Text</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>a stratum — or a unit?</td>
<td>F: The next distinctive bed is a fine-grained sand—and siltstone.</td>
<td>Note that hyphen after &quot;sand&quot; is a post-facto interpretation.</td>
</tr>
<tr>
<td></td>
<td>C: Check. How thick? F: It's about two feet thick. Thin bedded to papery, small-scale cross bedding. (Pause) It is overlain by medium-grained sandstone four feet thick; fresh and weathered colors the same—pale orange to yellowish gray.</td>
<td>&quot;Loose&quot; terminology ok if F and data center have agreed on common definition.</td>
</tr>
<tr>
<td></td>
<td>C: OK. F: Hold on a minute. That last sandstone that I just described to you—the light-colored, medium-grained sand—should be given as a special unit within a main bundle of rocks that consist of two principal types of which that is one.</td>
<td>Data center might well not automatically associate &quot;light-colored&quot; with the colors given above.</td>
</tr>
<tr>
<td></td>
<td>C: Hold on. (Pause) Could you go over that last discussion again?</td>
<td>Less ambiguous when written than when spoken, but certainly confusing.</td>
</tr>
</tbody>
</table>
Yeah. That last light-colored, medium-grained sandstone bed is just one unit in a bundle that consist of alternating beds of that type and another type.

C: OK. How thick is the bundle?

F: The bundle is about thirty feet thick.

C: Roger.

F: And it makes a weakly resistant ridge that stands up higher than the gypsum beds on both sides.

C: Roger.

F: It consists of that medium-grained sandstone interbedded with siltstone. The siltstone has the following colors: fresh color--yellowish gray and very light gray; weathers olive gray and brownish gray.

C: Weathers olive gray and brownish gray? Over.

F: That's right. That is a very thin-bedded unit--papery beds and sheets in beds two feet thick.

C: Roger.
F: Interbedded with that: medium sandstone that is very crumbly, and it's in beds two to four feet thick.
C: Roger.

Do you really mean more than just "lenses"?
F: Some of the beds are discontinuous, flat lenses.
C: Some of the sandstone or siltstone beds, or some of each?
F: ___________;______________

They are locally contorted moderately.
C: OK.

F: And that bundle is overlain by about ten feet of the reddish brown gyp shale.
C: OK.

F: And then the last distinctive unit in this whole(?) stack is about--just a minute (Pause)--consists of two very coarse-grained beds, each about four feet thick separated--hold on a minute.

Background voices: A: What unit was this now?
B: This is the last unit in
<table>
<thead>
<tr>
<th>Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>this little bundle.</td>
</tr>
<tr>
<td>C: Which bundle? I thought he said it was overlain by sand and siltstone...</td>
</tr>
<tr>
<td>F: I'll give you different dimensions. There are two main beds, each about twelve feet thick, separated by a poorly exposed gyp shale unit.</td>
</tr>
<tr>
<td>C: How thick's the gyp shale?</td>
</tr>
<tr>
<td>F: Ten feet.</td>
</tr>
<tr>
<td>C: Got some questions.</td>
</tr>
<tr>
<td>R: Hear me?</td>
</tr>
<tr>
<td>F: OK.</td>
</tr>
<tr>
<td>R: OK. You have a thirty-foot thick bundle of alternating sandstone and siltstone, and the way I have it, over that you've got ten feet of red brown gypsiferous shale as described previously, and above that apparently there is the two coarse-grained beds which are separated by a gyp shale unit. Is that right?</td>
</tr>
</tbody>
</table>

A summary from the data center, a valuable check for both data center and field man, especially in the case of a complicated description.
R: OK. Are you going to describe these coarse-grained beds a bit?

F: ______________. Medium to coarse-grained sandstone, thin-bedded--just a minute-- (Pause) They consist of quartz grains, subround to round. There are locally granule beds. Fresh and weathered color about the same, ranging from yellowish gray to pale yellowish orange.

C: OK.

F: This rock is very crumbly and makes subdued, rounded ridges.

C: OK. Does your previous description apply to both of these twelve-foot beds? Over.

F: There.....some chert and some rock fragments. Interrupted transmission. We lost part of your last description.

C: I'm sorry, we cut out part of your last description.

F: Composed mostly of quartz, but some chert and a few rock fragments. Interruption bespeaks poor radio procedure. Practice largely eliminates this problem.
C: OK. Now this description applies to both of these twelve-foot units?

F: That's right. Other mineral grains observed were: two (?) feldspars, a few pieces of dolomite and quartzite.

C: OK.

F: And that's overlain by more of the reddish brown and locally tan and gray gypsum shales.

C: OK, this bundle of silts and sands that you have been giving us--do these rocks make up that prominent ridge that we can see on our aerial photographs--the ridge that is dark to the west and light to the east?

F: That's right. That third sand and granule conglomerate that I just described is the light strip that's on the east.

C: Roger.

F: That was a pretty crummy description, wasn't it?

It's hard to believe that the "silts and sands" must be the same as the "sand and granule conglomerate."
<table>
<thead>
<tr>
<th>Activities</th>
<th>Text</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gives geographic position</td>
<td>F: I have the following coordinates: (garbled transmission)</td>
<td>&quot;Check&quot; suggests the end of a &quot;quantum&quot; of data.</td>
</tr>
<tr>
<td></td>
<td>C: I have coordinates five point, Hotel point three-eight. Correct?</td>
<td></td>
</tr>
<tr>
<td>Specifies marginal communications</td>
<td>F: You're coming in intermittently. Say again.</td>
<td>&quot;Over&quot; indicates end of one complete subject before presenting another.</td>
</tr>
<tr>
<td></td>
<td>C: Your coordinates: five point eight, Hotel point three-eight. Over.</td>
<td></td>
</tr>
<tr>
<td>Confirms coordinates</td>
<td>F: Roger. I'm on the east side of the broad wash that cuts across those alternating light and dark beds on the photos. I'm at the west edge of the southernmost dark bed. Over.</td>
<td></td>
</tr>
<tr>
<td>Keys discussion to photo-geologic planning done before traverse.</td>
<td>C: Roger.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F: You hear me?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C: Yes, go ahead.</td>
<td></td>
</tr>
<tr>
<td>Gives stratigraphic position</td>
<td>F: I'm in the middle part of Photo-unit four, at the top of what I'm reasonably sure is the reddish-brown gypsum and shale unit I described yesterday afternoon. Check?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C: Roger. You're at the top of Unit four-Charlie. Do you want any descriptions of the lower units read to you? Over.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F: No. I'll start at my coordinates, at the base of Unit four-Bravo, and describe that going up section. Over.</td>
<td></td>
</tr>
<tr>
<td>C offers reference to data center's records at what he deems an appropriate time.</td>
<td>C: Roger, go ahead.</td>
<td></td>
</tr>
</tbody>
</table>
Indicates his plan for describing Unit 4-Bravo.

F: Unit four-Bravo is four-zero or five-zero feet thick; I'll break it down into four or five subunits and describe them separately and in detail. Over.

C: Roger.

Describes Subunit I

F: The lowest subunit is a two-foot bed of siltstone. Fresh color--pale yellowish brown, weathered color--between light brown and moderate brown. Check?

C: Check.

F: The siltstone is thin-bedded, beds typically two to three centimeters thick; it has ripple marks, and crossbedding that typically transects three or four of the thin beds. The siltstone contains about one-five percent very fine sand--half of that quartz and half gypsum. Over.

C: Roger.

Describes Subunit II

F: The next subunit is a ten-foot bed of reddish brown gypsiferous shale. Check?

C: Check.

F: Very poorly coherent; tends to weather into a shallow trough. Its general appearance is like that of the red gypsiferous siltstones lower in the section. Over.

C: That would be the siltstones of Unit four-Charlie?

Describes Subunit III

F: Affirmative. The next distinctive subunit is a two-foot bed of fine-grained sandstone and siltstone. Check?

C: Check.

F: Fresh color--light gray; weathering color between olive gray and olive black. Check?

C: Check.

F: Bedding two centimeters to paper-thin, typically one or two millimeters. Occasional cross-bedding that typically involves a few individual beds. Over.

Use of "four-zero" (as opposed to "forty") is good radio practice to avoid misunderstanding.
C: Roger. Could you comment on the proportion of fine-grained sandstone in this subunit?
F: Roger. About three-five percent.
C: Roger. Thank you.

F: The next subunit is a medium-grained sandstone, four feet thick. Check?
C: Roger. Check.
F: For the sandstone—fresh and weathered colors the same—between pale orange and yellowish gray. Check?
C: Check.
F: Correction on that description—check?
C: Roger, go ahead.
F: The next subunit, going up section, is a three-zero-foot-thick series of two alternating rock types holding up a weakly resistant ridge that stands slightly above the non-resistant gypsum beds on either side. Check?
C: Check.
F: The two rock types occur in roughly equal amounts; they are the medium-grained sandstone that I just described, and interbedded siltstones. I'll finish describing the sandstone. Check?
C: Check.
F: The sandstone is very poorly coherent even though it makes a low ridge. It occurs in beds that are typically two to four feet thick, and that tend to be thin lenses. These lenses typically extend for about three-zero feet along strike: the beds within them are locally contorted. The lenses very probably represent stream channels and the deformation is probably due to slumping.

Orderly way of correcting previous (incorrect) definition of Subunit IV.

F feels that these interpretations need no further documentation. He would probably take photographs.
C: Roger.

Describes Subunit IVb

F: The interbedded siltstone has fresh color between yellowish gray and very light gray weathering color olive gray and brownish gray. Check?

C checks poor transmission.

C: Weathers olive gray and brownish gray? Over.

F: Roger. It has papery sheets and laminae a few millimeters thick in beds typically two feet thick. Over.

Describes Subunit V

F: This subunit is overlain by a new subunit that I'm distinguishing on the basis of color; this new subunit has four members. Check?

C: Check.

Describes Member 1

F: The lowest member is a ten-foot bed of reddish brown gypsiferous shale; next is a one-two-foot bed of medium- to coarse-grained sandstone. Check?

C: Check.

Describes Member 2

F: The next member is another ten-foot bed of red gyp shale, and finally, another one-two foot bed of sandstone like the previous one. Check?

C: Check.

Describes Member 3

F: I'll describe these two rock types now in more detail. First the gyp shales, check?

C: Check.

Describes Member 4

F: The shales are generally reddish brown, but locally tan and gray. Apart from their colors, they're apparently the same as the red gyp shales in Unit four. Over.

C: Roger.
Describes Members 2 and 4

F: The sandstone beds are very poorly coherent, but resistant enough to make subdued, rounded ridges. Check?

C: Check.

F: Fresh and weathered color about the same--ranging from yellowish gray to pale yellowish orange. The gray colors are predominant in the lower part of the section. Check?

C: Check.

F: Dominant grain size is medium to coarse sand; occasional granule beds four or five centimeters thick make up about ten percent of the rock. Check?

C: Check.

F: Grains are subrounded to rounded, very dominantly quartz, with a few percent feldspar grains--both orthoclase and plagioclase--and scattered grains of dolomite and quartzite. Over.

C: Roger. Two questions: first--this subunit differs from the previous subunit in that its finer-grained beds are red-brown gyp shale rather than yellowish siltstones and its sandstones are medium to coarse with granule beds rather than strictly medium-grained. Check?

F: Check.

C: Roger. Last question: do these interbedded sandstones and siltstones make up a ridge on our photos--the ridge that is dark on the west and light on the east?

F: Affirmative. The third member--the upper coarse sandstone--is the light strip on the east. Over.

C: Roger.

F: That was a pretty good description, wasn't it?
### HYPOTHETICAL "GOOD" DESCRIPTION

<table>
<thead>
<tr>
<th>Activities</th>
<th>Text</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checks with data center.</td>
<td><strong>DF ready?</strong></td>
<td><strong>&quot;Housekeeping&quot; information for the station.</strong></td>
</tr>
<tr>
<td>Gives geographic and photo-geologic location.</td>
<td>I'm at Station one-six, coordinates Echo point eight, four point four (in Photo/unit six).</td>
<td>Phrase &quot;good view&quot; suggests reliability of data. Specifying the number and type of descriptions to be given prepares data center.</td>
</tr>
<tr>
<td>Specifies number and type of descriptions to be given from station.</td>
<td>I have a good view of the surrounding country, and I will give you four remote descriptions.</td>
<td>Housekeeping information for first description.</td>
</tr>
<tr>
<td></td>
<td>Check?</td>
<td>General location adequate for data center to find previously defined feature on photographs. Phrase &quot;general view&quot; suggests amount of detail and reliability of description.</td>
</tr>
<tr>
<td></td>
<td>Remote Description one, of faults Foxtrot and Foxtrot One.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>General location of target: Bravo point seven, two point eight.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Photograph: One-six dash one, bearing two-two-zero, general view of fault area from this station.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Check?</td>
<td></td>
</tr>
<tr>
<td>Specifies location of new fault and keys it to photomap.</td>
<td>In this area, fault Foxtrot is correct as mapped, and I will say no more about it. There is another fault, however, that has not been mapped and that is parallel to, and about one-zero-zero feet to the south of, the first one. It is visible on the photo as an indistinct dark line. I will call it Foxtrot One.</td>
<td>Minor application of problem solving method.</td>
</tr>
<tr>
<td>Activities</td>
<td>Text</td>
<td>Comments</td>
</tr>
<tr>
<td>------------</td>
<td>------</td>
<td>----------</td>
</tr>
<tr>
<td>Gives criteria by which fault can be recognized.</td>
<td>Check? The fault plane itself has no topographic expression, but the trace of the fault is defined by different color on opposite sides of the fault and by offset of small gullies and ridges that follow strike of rocks. Offset key beds indicate a left-lateral separation of about six-zero feet. Check? Dip of fault plane is poorly expressed, but probably subvertical. I cannot trace the fault toward me, owing to poor exposure--it may or may not continue through the vicinity of this station. Over.</td>
<td>&quot;Check&quot; indicates that more information is forthcoming. Data center may be able to see this on photo--once they know where to look. &quot;Over&quot; indicates end of transmission and encourages questions.</td>
</tr>
<tr>
<td>Documents his interpretation.</td>
<td>Remote Description two, unconformity between Photo unit six, below, and Photo unit seven, above. Location of target: to the south of station, general area of Echo point four, one point six. No Photographs. Check?</td>
<td>Housekeeping information for second description. Generalized location quite adequate in this case: serves mainly to orient people in data center.</td>
</tr>
<tr>
<td>Ties stratigraphy to geomorphic characteristics.</td>
<td>Basal conglomerate of Unit seven forms massive cliff at the top of ridge. Dip about four-five east, strike roughly north. Scattered exposures of Unit six on slope below cliff show that Unit six is beveled by the conglomerate of Unit seven in such a way that progressively younger beds are truncated to the north. In other words, Unit six has a more westerly strike than does Unit seven. Check? From here, the apparent angle between beds of Unit six and Unit seven is about zero-four degrees, opening to the north. To get a more precise figure, you can note that the resistant beds on which I am standing are truncated by Unit</td>
<td>This complicated description shows how difficult it is to convey &quot;geometric&quot; data in words. This allows data center to improve on observed value by means of calculated value.</td>
</tr>
<tr>
<td>Gives clarification of difficult concept.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This allows data center to improve on observed value by means of calculated value.
Keys his observations to photomap.

Seven at coordinates Echo point three-eight, one point eight. You can see that on the photo. Check? From here, the unconformity seems rather smooth on a large scale, being characterized by swells and swales commonly several hundred feet in wavelength, and with amplitude of only a few feet or tens of feet. There seems to be no conspicuous coarsening of the conglomerate in the swales. Over.

Remote Description three, of fault Foxtrot.
Location of target: Golf point one, four point eight-five, to the northeast of station.

Photographs: One-six dash two, one-six dash three, bearing zero-six-five.

Check?

Relates geology of target to geology of station.

I'm looking at the northeastward continuation of fault Foxtrot, on which I am standing. The fault is correct as mapped, but I can fill in some details. Check? The strike of the fault between present station and target is zero-six-five. At target, where the fault is well exposed in the gently sloping side of the valley, dip of the fault is six-eight degrees to the south. Check? From here it looks as though the red beds of Unit eight, north of the fault, are juxtaposed against the basal conglomerate of Unit seven on the south. The fault is actually a fault zone generally similar to that described for fault Charlie a few stations ago, but differing in that the width of the fault zone seems to vary along strike, ranging from about five feet to about five-zero feet, and typically being about one-five feet. Check? Within a zone

Establishes setting and specifies reliability of his observations.

Field man obviously looked for something he expected, without finding it. Possibly a very important observation.

Amends photomap.
Describes by comparison and contrast.

Field man neither gives, nor should be expected to give, exact station number. Both range and average value of measurement are given.

Housekeeping information for third description.

Field data confirming and augmenting photogeologic data.
Applies problem solving method.

about one-five-zero feet wide and centered on fault Foxtrot, there are several subsidiary faults that are subparallel to Foxtrot and show left-lateral separation of ten feet at most. I can also see some drag of which I have sufficient three-dimensional exposure to make me think the idea of oblique slip—was that hypothesis "b"—is the correct one for this area. More on this later, after I've traced the fault to the northeast.

Over.

Remote Description four, stratigraphic section exposed to the south of station.

Location of target: vicinity of Echo point six, three point one.

Photographs: One-six dash four, bearing one-eight-five.

Check?

Define what is going to be described.

Gives geomorphic characteristics.

Gives attitude. Gives information on exposure.

I am going to describe a stratigraphic section of Photo-unit six below the angular unconformity at the base of Unit seven and above the basal, resistant, member of Unit six. Check? The section in question is geomorphically weak and forms a strike valley down which I can look. The bottom of the section coincides with the lowest part of the valley. Strata dip east about four-five degrees. Exposures are moderate to good, and in the form of an oblique cross section. Check? The section is about two-five-zero

No unnecessary documentation given here. Data center should know which hypothesis is discussed. This statement should prevent the asking of untimely questions.

Housekeeping information for fourth description.

"One-eight-five" has three syllables, "one hundred eighty five" has six. Even though the former may look ponderous in writing, it is quicker to say, and certainly less easy to misinterpret over the radio. Section is treated as a "system", and properties of this system are briefly described.

Information on quality and form of exposure suggests reliability of data that follow.
feet thick and apparently conformable; it can be broken down into three members, distinguished by color, geomorphic resistance, and texture-composition. The lowest member, about one-three-five feet thick, is generally light greenish gray in weathering color, relatively weak in resistance to erosion, and probably composed largely of fine-grained sandstone or siltstone, locally interbedded with carbonates and possibly with gypsum. Check? The middle member, about three-zero feet thick, is medium to dark brown, relatively resistant to erosion, and probably composed largely of sandstone. Check? The upper member, about eight-five feet thick, is brick red, relatively weak, and composed mostly of fine-grained detrital material, probably siltstone. Check? From here I can see no evidence of disconformity between the various members. The beds appear consistent in attitude and undisturbed by faults or folds. I will now give more detailed descriptions of the three members, starting from the lowest. Check?

Mentioning the conformable relationship at this point helps the data center in constructing sketch sections.

The three members are treated here as "components" of the section being described ("system") and are described in detail sufficient only to define them. Sequence followed is: dimensions, color, weathering characteristics, composition texture, structure. Information on texture-composition given in a remote description is tentative, of course. Nevertheless, a field man experienced in the weathering characteristics of various rock types in the climate of the area studied can be remarkably successful in identifying from a distance the gross texture-composition of a rock. Important for data center to know that field man has considered the possibility of discontinuities in the section before describing it. This prepares the data center for the "more detailed" description that is to follow. The preceding general description allowed the data center to make outline sketches, to be filled in by the more detailed data. Lower member is not treated as "system". Exposure, color. Weathering characteristics.
Defines components of lower member.

1) one-third or so is somewhat more resistant and forms a ledgy slope. Check? Three interbedded lithologies can be recognized: first, medium to light greenish gray, very fine-grained sandstone or siltstone, about seven-zero percent of member; second, medium gray to white, banded poorly resistant rock, probably gypsum, about ten percent; third, medium gray, bedded carbonate, about two-zero percent. As mentioned earlier, the lithologies are interbedded, but the carbonate, which forms up to about four-zero percent of the lower third of the member, decreases to zero higher up. Check? The siltstone and gypsum appear to have indistinct bedding; the carbonate occurs in beds one-half to one and one-half inches thick. No primary or secondary structures are visible from here. Both upper and lower contacts appear conformable. Check? The middle member is well exposed in cliffy cross section. It is moderate brown, five Yankee Romeo four slash four, to moderate yellowish brown, ten Yankee Romeo five slash four, in weathering color, and thus is easily distinguished from other members of this section. Check? Weathering resistance is greater than that of the other two members. Only one lithology is present, namely, sandstone, probably rather coarse grained, of various shades of brown. Locally, however, there are thin and irregularly distributed lenses of finer-grained, reddish brown material, probably siltstone. Other lenses are probably composed of coarse sandstone and contain pebbles as much as two inches in diameter. From here I cannot give a reliable estimate of the average pebble size. Check? Bedding is irregular, festoon cross bedding common. I think I can see graded bedding

Composition. Lithologies treated as "components".

Distribution of lithologies.

Structure

Middle member treated as "system". Exposure, color.

Distinguishing characteristics.

Composition. Lithologies treated as "components."

Does not give distribution of lenses, as this would be inappropriate at this level of observation and could easily be documented in a photograph.

Does not give information that would be unreliable and possibly misleading.

Defines components of middle member.

1) (here only one component)
in some of the coarser-grained units. From this vantage point, I see no evidence of channeling at the base of the member, even though I would expect some, as I think the member is a stream-laid deposit. Check?
The upper member is moderately exposed in oblique cross section. The weathering color is moderate reddish brown, ten Romeo four slash six, irregularly veined with grayish pink, five Romeo eight slash two. Check? Weathering resistance is low; the member forms a gentle slope cut by gullies which give good exposures. Only one lithology is exposed, namely a very fine-grained detrital material, probably siltstone, which, however, is laced with the irregular veins mentioned earlier. These veins have various orientations and may represent discoloration along fractures, or veins of a secondary mineral, possibly selenite. Check? Bedding is indistinct or massive. No joints can be seen from here.
The upper contact, with the basal conglomerate of Unit seven, is distinctly irregular on a large scale, inasmuch as I can see swells and swales several hundreds of feet in wavelength and several feet to several tens of feet high. In detail, however, the contact appears smooth. Over.

NOTE: As an illustration of one of the advantages of using a data center, consider how long it takes to read—and to transmit—the above amount of information, and then think how long it would take to record all this in a notebook. A notebook recording would almost certainly be less comprehensive and complete.