The Development of Precision In Locality Notations: Some Classical and Some Modern Methods

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Field collectors today can learn from the mistakes of the past when recording the sites of their discoveries. Otherwise, many localities which may be well-known today could become the lost localities of tomorrow. Modern technologies such as GPS (Global Positioning Systems) offer the opportunity to achieve significantly greater precision when their reference grid systems of notations are fully understood.

Introduction

We have all heard stories of vague or lost or missing mineral localities, and it is rarely that we have the time and energy to search for some of these. Sometimes they can't be found, and the reports of them remain only to tantalize us. Wilson (1983) related some of the difficulties of locating sites in his fascinating paper on lost mines in Arizona. This has surely been a common thread of conversation among mineral collectors from time to time, and we all wish that someone had been a little bit more careful about describing a location or, more accurately, describing exactly where it is.

This problem was discussed by Neal Yedlin in 1976. He said that when a collector neglects to label his finds immediately, visits more than one locality, and then later trusts to memory—whether after a week or two, or after prolonged storage—the labeling can be in error by quite a bit.

One example of a vaguely described locality was mentioned by H. H. W. Stillwell in *The Mineral Collector* in 1902 (and cited by Yedlin in 1976). Yedlin said that Stillwell had tried to give the details of the find, giving the directions as nearly as he could remember them: "When you leave the trolley at

Farmington take a road running north (I cannot say just which road), follow this road for five miles. At a cross road turn to your left and go 5 miles further, then turn – well I am not sure which direction it is, but I think it is either north or south; follow this road for 5 miles and then cut across the fields for 5 miles more...” In this case the road to take was in doubt and the distances were on the order of several miles, leaving a large degree of error, so that the site could not have been found except by accident. Perhaps the author wrote it as an example of a vaguely described locality.

In 1936 Horace Slocum wrote “A Half Mile Mistake,” about trying to find the topaz deposit reported by George F. Kunz as being located on “Harndon’s Hill” in Maine. The search took quite a while, and by the fifth page of the narrative Slocum had come to the deposit on the neighboring Lords Hill. He only found why the report was mistaken when later, after his article had appeared, a letter by a Mr. Marble revealed that the names of the hills had changed. Perhaps, as in the case of Witt’s Hill, the USGS mapmakers had moved the name of the hill to another place (King, 1989). Cole in 1961 told of various lost localities which are difficult to find today because of the method of locating back then (usually on someone’s farm, that someone having been dead for over a hundred years). Many collectors now attempt to label localities better than before; still, Dunn (1991) stated that many specimens collected in the eastern U.S. are accompanied by little useful locality data on their labels. He advocated the use of better documentation and locality reference systems.

Early Methods of Site Designation

The history of locality documentation is characterized, more or less, by gradually increasing precision. The term “precision” refers only to the specificity of detail; “accuracy” is freedom from error. For example, if one says that a mine is 1.25 miles in a certain direction from the town square, when in fact the true distance is 2 miles, the first statement is more precise but the second more accurate.

Perhaps the oldest reference to a named mineral locality is in the Bible. Ophir, first mentioned in the book of Job, was famed for its gold. King David of ancient Israel donated several thousand talents of Ophir gold to the temple project, and later a descendant of his, who attempted an expedition to Ophir, had his fleet suffer shipwreck at the head of the Gulf of Aqaba, an arm of the Red Sea. Ophir may have been in that direction, but it could only be speculated that it lay somewhere in southwestern Arabia. A more modern report indicates that some USGS geologists working in that area found that one site of ancient workings, reworked from 1939 to 1954 for gold and silver, in a place called *Mahd adh Dhahab* (“Cradle of Gold”), could have been the Biblical Ophir, considering that the ancient waste rock was rich, and ancient mining tools littered the area. Obviously the ancients knew how to find it at the time, but that knowledge was subsequently lost.

In this country in the early 1800’s, mineral localities were often described by town and state, and little effort was made to provide more precise locations. Such was the case in 1825 when Samuel Robinson’s *Catalogue of American Minerals with Their Localities* was published. Presumably the original finder, usually a local and known to his fellow townsmen, could guide a visitor to the sites. In later years, localities were more commonly described as being on someone’s farm or estate, in a town, county, and state. This was useful when lands were cleared and the owners were glad to show mineralogists the sites, but many aren’t so easy to relocate now, after brush has covered some lands and the former owners have long since passed away. Some county maps published in the late 1800’s may be used (some have been reprinted in book form) to try to find where someone lived, as names, at least surnames and first initials, were often indicated on these maps. However, without more detailed data, or lengthy research, many of these mineralogical sites may not be locatable today.

Later on, in the 20th century, mines were often described by the mine name, sometimes also by the road or section of town, then the town, county, state or province, etc. This still-used method is good, provided that the mine has retained its original name over the years (some have changed names many times), and that the location of the mine has been described in some published reference still available to the researcher. However, it is still a maxim that it is not the name of a locality that matters as much as its location upon the face of the Earth. Unless one can find it again, either on a map or in the field, then one doesn't really know where it is, even if its name is known.

Localities are often described by natural, or landscape features, or by manmade, or cultural features. Natural features generally stay put, although their names may change (note that Laurel Hill in Secaucus, New Jersey, was once known as Snake Hill, and Bergen Hill is an older designation not presently used in current topographic maps, although mapped in a few older mineralogical references). Cultural features are also useful, but subject not only to changing names, but also to changing town centers. Road names, numbers, and junctions also can be changed in time. Cemeteries which are shown and named on topographic maps can be useful points of reference, as they seldom change. Many cemeteries, however, have been reclaimed for other uses once they were no longer being visited by the living.

Some sites are described by a trail, or by directions on how to get there. This is fine when the trail stays put, but the effect of storms, logging, erosion and growth can obliterate a trail, or at least render it indistinct. Unless a trail is marked on a permanent map such as those of the USGS (U.S. Geological Survey) topographic series, a site on the end of a trail can be like a fish on the end of a fishing line—only good as long as the line holds. Conversely, a trail or way of access can be very useful information to accompany an accurately located site.

In some cases a site has been described as being "along" (how far along?) a certain water course in a specified area. However, this can generate ambiguity unless its name is known to be unique in the area. An example was reported in 1971 by Earl Pemberton: A site was described in a professional journal as being situated "by Birch Creek" within a certain National Forest, but unfortunately there are *five* Birch Creeks within that Forest. Which one was it? Specific locality data would have been better.

Local names can also confuse. An example is a report by Ward (1964) regarding a discovery made on "Emerson Mountain" in Madison, New Hampshire. This name is not found on any topographic maps either old or new. It may be best to use references already named on topographic maps, or in other commonly available references. If a hill appears to have no name, on the map or in mineralogical literature, then one may use its peak elevation, particularly if it has a specific elevation noted on the map. Thus Emerson Mountain is better described as the "1322-foot hill 2 miles northeast of Madison, New Hampshire"

Road cuts may be a special case, and should be described so that one can find them again. It is confusing to read a label such as "Roadcut, Raymond, N.H." when there are several roadcuts along miles of highway there. It is far better to indicate the road and the *year* (which may help indicate later whether the find was made during road construction), along with mileage from a known point in a direction along the road. An example of a good locality description might be "Roadcut, new Rt. 101 (1983), 0.7 mile west of Main St., Raymond, N.H." In this case exact bearings are not needed, inasmuch as one measures along the road from the landmark named on the topographic map. Just be sure that the landmark is actually named on the map; don't use freeway exit numbers, which later can be changed.

Often a locality, such as a named mine, is mentioned as being "near" a certain town, although it may not be within the political boundaries of that town. This may be fine for some places, (in which the matrix can be found in only one place), but it is usually better to specify a particular hill or some other more precise designation.

More precise methods of describing locations are based on maps, usually (in the United States) USGS topographic maps. These methods are predicated on the idea that the recorder actually knows exactly where to plot the site on the map. In some cases this may require a little surveying, or at least some pace-and-compass work, to obtain bearings and distances from landmarks on the maps.

The bearing-and-distance method measures from landmarks shown on the map and found in the field, using a bearing and distance to the mineral location, or vice-versa (the method is discussed in some of Sinkankas's books), with accuracy and precision often depending upon the precision of the bearings and distances obtained or calculated. This method also depends upon the precision, or perhaps the imprecision, of a starting point, such as a village (where in the village does the distance start?), the permanence of the starting point, and the permanence (when used) of route numbers (Merrill, 1986). For compass readings, notation of whether true north or magnetic north has been used may help to alleviate later dilemmas. This advice should be followed by geologists as well! The location of a site described as a certain distance N 34° W from a landmark is ambiguous when one doesn't know whether true or magnetic bearings were meant. It may be useful to note which bearing was used in the field and then, if needed, calculate the other at home, recording which one along with the bearings (the previous example could have been noted either as TN 34°W or MN 34°W). It is sometimes easier when plotting localities on a map to first draw, with a light pencil, a few lines of magnetic north. The magnetic declination (difference between true and magnetic north) is indicated to the nearest half degree on topographic maps in the bottom margin of the sheet. The star refers to TN, or true north, along which the sides of the map are oriented, and the MN indicates magnetic north. GN refers to "grid north," the difference between the map grid and true north.

The Public Land Survey System used in many states west of the Appalachian Mountains provides a mapping grid over large tracts of land. In this system land was divided into (usually) square townships 6 miles on a side, these being subdivided into 1-mile-square sections, 36 per township. These sections are shown on 7½-minute topographic maps by red lines spaced one mile apart, and numbered in red numerals. In the land surveying system the sections can be subdivided into a succession of quarters or halves (such as the N half of the NW quarter of the SE quarter of Sec. 25). Such notations are fine for dividing up farmland, but for the designation of mineral locations they are not always sufficiently precise. One could use certain section corners, if locatable in the field, as landmarks from which to further locate a site. But as Foerster (1992) suggested, suitable permanent landmarks are often lacking in certain terrains.

Another useful method is referred to by surveyors as the "latitude and departure method." It entails measuring the distances, north and east, of a site from the edges of a stated map (or, in some cases, from a landmark on the map). In this method it is important to note which distance was North and which was East (or West as the case may be; note which is used), and to note the units used, whether in cm, or in scale feet or meters. The first would be cm on the paper map, the second is the distance scaled from the map, which would correspond to the field. Jacobson in 1987 used this method to describe locations by their positions, in terms of so many scale feet in two directions from a corner, or edges, of a designated topographic map. One example was "7,500 feet W from and 5,850 feet N from" the SE corner of a named map.

Coordinate Grid Systems

Coordinate systems have been used for years. Some have been based upon individual maps while others have been based upon more far-ranging systems. It is best to use a system that is compatible with the common topographic map series. In the case of state plane coordinates, sometimes offered as a possibility, these do not appear compatible with the topographic map series (they have very few grid references on the maps), and furthermore they tend to differ from state to state, and therefore have the disadvantage of a lack of universality. However, there are coordinate systems that can be used on most topographic maps in the U.S. and Canada.

The Kemp Ninth Coordinate System has been used in some references. This system divides a USGS topographic map quadrangle into nine sections, each of which has a numeral (from 1 to 9); then each section is divided into nine smaller ones, each with its numeral, and so on in ever-decreasing size, until by the fourth numeral (in the case of 7½-minute maps), or the fifth numeral (in 15-minute maps), the site has been located on the map with an error of precision better than previous methods. In the case of a 15-minute map of 1:62,500 scale, the fifth numeral indicates a rectangle of about 375 feet in length by somewhat less in width. This system was outlined by Kemp (1905), and was explained in Samuel Gordon's *Mineralogy of Pennsylvania*, which used it in some cases; it was also discussed in the Ives article in 1947. A slightly modified form of the system was used in *New Hampshire Mines and Mineral Localities*, by Philip Morrill (1960). If needed, these coordinates can be converted to latitude-longitude coordinates, although not of the precision that the latter terms may imply.

The two most useful coordinate grid systems are the latitude-longitude system and the Universal Transverse Mercator (UTM) system, both used in most of the GPS (Global Positioning System) receivers. The UTM grid has been used so much in conjunction with GPS that it has sometimes been referred to as the GPS grid, but that is a misnomer. These two systems can be used worldwide, and their grid ticks may be found in the borders of topographic maps of the U.S. and of Canada.

The latitude-longitude system is based on a spherical Earth, with 360° in a full circle. Each degree is made of 60' (60 minutes), each minute of 60" (60 seconds). For latitude, the equator is 0° and the numbers go to 90° north or south at the poles. For longitude, the meridian passing through the Royal Observatory at Greenwich, England, is taken as 0° (the "prime meridian"), and the numbers go to 180° east and 180° west. This system has been used for centuries by navigators, and later in land mapping, and in the topographic map series of the U.S. and Canada. These maps are bounded by the parallels of latitude and meridians of longitude. Map areas in the past have been in 15-minute (¼°) parts, and much of the U.S. has by now been mapped in 7½-minute maps. More information on this is given in the book by Thompson (1979) published by the U.S. Geological Survey. A discussion regarding the use of this system to pinpoint localities may be found in Morong (1992).

Readouts of latitude-longitude may be set (and read) in most GPS (Global Positioning System) receivers in either degree-minute-second format, or in degrees, minutes and decimals of minutes, or simply as degrees and their decimals. It should be noted that in North America the coordinates in this system increase toward the north and toward the west.

The Universal Transverse Mercator (UTM) system is a grid based on the metric system. This grid may be noticed on some of the 7½-minute topographic maps; on these large-scale maps the grids are spaced 1 kilometer (1000 meters) apart. The 1:50,000 scale topographic maps in Canada also show these grids. Some of the 7½-minute series USGS maps do not show the grid, but nearly all, particularly the newer ones, do at least show the grid ticks with their numbers along the borders. Straight lines may be drawn between grid ticks of equal number to form the grid. The numbers are the number of kilometers and meters, and these numbers are usually run together when written, whereas some find it easier to record them by placing a decimal between the km and meters (e.g., 342.870). In this system, numbers increase toward the east (opposite from that of the latitude-longitude system in North America), and toward the north. Some GPS readouts may show the Easting first and then the Northing, but other receivers show it the other way.

Because the Earth's surface is curved and flat maps are not, such a square system would eventually run into problems on a spherical Earth. This difficulty has been minimized by dividing the face of the

Earth into 60 zones, each 6° wide, and using a central meridian 3° from its borders. Each zone therefore uses the same basic system, and error is held to a minimum by stopping a particular zone before the error multiplies beyond a given limit, and then beginning the next zone. As an example, the area of the contiguous U.S. is divided into 10 zones, from zone 13 to zone 19, from 126° to 66°, with a zone border along a meridian of longitude every 6°. Of course, in North America, Canada and Alaska add to the width and to the zones. The zone number is noted in the lower left hand corner of each modern USGS topographic map (and usually somewhere on each GSC topographic map), and is included along with the UTM coordinates shown on readouts of most GPS receivers.

Maps of areas near the center meridian will show grids fairly well aligned with the map borders (map borders being along meridians of longitude), but the grids appear angled in maps far from the central meridian. The grids are not skewed—the maps are, because these are not true rectangles, but rather quadrangles based upon the curvature of the Earth. The top and bottom edges of the maps are gradual arcs, corresponding to the curved parallels of latitude on the Earth. The sides of the quadrangle are straight lines which are not parallel to each other, but move closer to each other on ends closer to the poles (and the closer to the pole, the narrower the map). This difference between the top and bottom borders is hardly noticeable or even measurable on the topographic maps of the 7½-minute and 15-minute series, but can be seen on maps of 1:250,000 scale (where an inch on the map represents nearly 4 miles), which show much larger areas and therefore show better the curvature of the Earth. The amount of divergence between true north and the grid, or grid north, is usually noted somewhere on each topographic map.

Although the UTM system is metric, it is easier to use, at least on maps which contain its grid, than other systems. Everything is by tenths, and any map of a particular scale, such as 1:24,000, needs only one scale to measure within a grid. Usually a photocopy of the kilometer scale, shown in the bottom margin of the map, will work when a paper copy is folded at the bar scale to expose it; this shows tenths of km's and may be estimated to hundredths. The last digit, the meter, shown in GPS readouts has little significance, as most hiker GPS receivers are not very accurate, and although they may show readouts to the nearest meter, they may contain errors of up to 10 meters, or about 30 feet.

A good explanation of the UTM system was given by Terry (1996) in the magazine *GPS World*. Although having previously used the latitude-longitude system, I read it and soon learned how useful and easy the UTM system really is. Some, however, use the MGRS (Military Grid Reference System), which is a variant or extension of the UTM system; it substitutes letters for certain numbers, and may decrease the number of digits based on the lesser precision used. However, the plain UTM system is easier to read and use, and it is best to include all of the numbers for placement, unless of course one leaves off the meter digit, in which case a decimal point between kilometers and its parts may be used. Some programs use a system of differently sized numbers to indicate km and meters, but it is simpler just to insert a decimal point between them.

As with other things, advances in technology often go with advances in precision, and we today may have advantages and opportunities not previously available. GPS receivers, the type sold to hikers, may now be bought at prices beginning around $100 (U.S.), and though they may display readings to the nearest meter, they usually have a claimed error of about 10 meters (about 30 feet), which is usually sufficient for locating prospects. Depending upon local conditions, such as terrain and tree cover, and upon placement of the satellites from which they get signals, the error can range from much more than that to less. Many units now indicate the number of satellite signals satisfactorily received; usually a minimum of four good, well spaced, satellite signals will get the claimed accuracy. Some later models even note the error of precision. These units are good at getting horizontal coordinates, but don't expect much from elevation readings, as many do not do well with them. Most units can be set to display either latitude-longitude or UTM coordinates. Some can even be used in converting from one system to the other, by entering and storing a point in one system, then changing the system and getting a display of the coordinates in the other system.

I bought a GPS receiver at a yard sale for a low price. It apparently worked at the sale, but checking it later revealed an error of about a third of a mile. The seller may have thought it inaccurate, but when I reset its datum from a foreign one to the datum of NAD27, used on many topographic maps, it was right on target thereafter. I checked mine by traveling to several known points on the map, after having interpolated the coordinates from the map, and all were within scaling tolerances, or within the stated precision of the unit.

There are two main datums used with GPS and with topographic maps. NAD27 (North American Datum of 1927) has been used on most USGS topographic maps since then; the datum used is mentioned in notes in the lower left area of the map margin. Newer maps have an additional, and dashed, corner tick near each corner, and this refers to the other datum, such as NAD83 (some of the newest maps use and note NAD83 as their main datum). In terms of latitude-longitude coordinates, the two datums appear usually not too far apart (their differences can be seen in the two sets of tick marks found in the corners of many topographic maps). However, inasmuch as the UTM coordinates are not only scaled to more precise figures but can also show a considerable difference between the two datums—in some cases up to a few hundred meters for the same point—it is wise to set the GPS device to whichever datum is used on the map.

Some GPS units do not list NAD83, but instead use WGS84 (World Geodetic System of 1984). One may use WGS84 in place of NAD83, as for our purposes these two are practically the same. The difference between these, which in most areas of the continental U.S. is less than 2 meters, may be of importance in geodetic work but is less than the inherent error of precision in a hiker GPS model. But whether one uses NAD27, or NAD83~WGS84, it may be useful to note which system is used when recording coordinates. Considering the amount of imprecision inherent in many past locality designations, it may be thought superfluous to worry about which datum is used, unless one wishes to pinpoint a small and easily lost site. However, because it can make a difference, one may as well use the correct datum if one is to specify this level of precision.

GPS receivers do not actually guide a person, unless one has experience with them and has already entered the coordinates of a site and is willing to follow a straight line to the site (they are useful, however, in guiding one back to one's car, if one has entered the coordinates of where the car is parked for where it is now, and not for where it was on last week's trip elsewhere). GPS receivers obtain coordinates from signals given by satellites, and it is these coordinates that can be plotted on a map. Ream (1995) has supplied good hints on using one. Of course if one does not have a GPS device, a bit of pace-and-compass surveying may be practiced as long as there are sufficient landmarks to do so, to later plot on the map, or to interpolate coordinates from the map, as described by Morong (1992). It is advisable to avoid totally relying upon any GPS, and to use a compass and a copy of the map, because these don't rely on advanced technology that can be broken, or on batteries which can run down. And maps also offer descriptive spatial information besides.

Topographic maps are available from several outlets, in several formats—both as paper maps and on compact disks – both online and in depository libraries, also sold in various places in the U.S. and in Canada (note that each usually sells only its country maps). Although paper maps are usually best, some have found that the use of topographic maps online or on disc, and a print function, is a handy combination for copies of small portions of maps.

There are available on the market various sets of topographic maps on CD-disks, along with attendant programs that may allow marking of points and routes and other conveniences. They also commonly allow pinpointing of coordinates (in either UTM or latitude-longitude; most programs have both). Some of these use real USGS topographic maps (usually the 7½-minute series), while others use what they call topographic maps but are somewhat different in character from the USGS ones (they may be based upon vector graphics rather than raster, or bitmap, graphics). Before buying any of these, it is best to check them out, perhaps on a friend's computer, or by a demo on the internet, to see what they really look like and how they work; actually seeing a product yields more information than the ads.

Coordinate databases may also be available in electronic form and sold at reasonable cost. One such database claims to include latitude and longitude coordinates for almost every mine and quarry in the U.S. This should be viewed with caution, though, as some who have tried out a few of those coordinates on known sites have found that many are simply not sufficiently accurate to be useful, and they hardly need 6 decimal places of degrees (corresponding to an implied precision of a fraction of a foot) when so many of the coordinates are in error by a tenth of a mile, and in some cases by up to half a mile or more. Such an abundance of digits without corresponding accuracy is false precision, and coordinates to 4 decimal places would have sufficed if they were accurate at all.

Coordinate notation has one disadvantage, however, and that is that a "typo" error, even in only one numeral, can throw the purported location off by quite a bit. The older classical methods, however, can often be interpreted or corrected even if a word is misspelled. So it is not recommended that localities or specimens be labeled only by their coordinates, but mainly by the classic methods, such as name of mine, town, county, state, etc., and possibly (such as in field trip data) the distance and bearing from some point; its coordinates, where needed, may be used in conjunction with customary methods. Of course, if a site is relatively unknown, its coordinates may be its only means of location. In any case locality data should be recorded, both on the specimen label and in either field trip notes or journals; the journals may include additional information such as the best way to get to a site.

It is best to record locality data as soon as possible after collecting. In some cases, especially if two sites of similar geology and similar specimens are visited within the same field trip or day, it may be wise to include a label with the material before leaving a site to go to the next site.

We have all experienced the confusion of incomplete or vague descriptions of localities, either on labels or in reports. Now that we have methods of achieving more precision, let us also be more accurate. Any site should be described so that it can be defined and found again, on a good map of the area, with no ambiguity or vagueness, but simply and directly. And all such information should be recorded promptly before time plays tricks on our memories.

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