RECOMMENDED STANDARDS FOR RECORDING THE LOCATION OF MINERAL DEPOSITS

A. M. KELLY

$0.75

Published by the Geological Survey of Canada as GSC Paper 72-9
Department of Energy, Mines and Resources, Ottawa

1972

G E O L O G I C A L   S U R V E Y

O F   C A N A D A

CANADA

PAPER 72-9

C A N A D I A N   C E N T R E   F O R   G E O S C I E N C E   D A T A

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Price: 75 cents Catalogue No. M44-72-9

Price subject to change without notice

Information Canada
Ottawa
1972

FOREWORD

One of the principal objectives of the Subcommittee on Computer Applications, National Advisory Committee on Research in the Geological Sciences, has been the development of standards for recording observations and measurements in the geosciences, in order to provide a basis for establishing the Canadian System for Geoscience Data, a computer-based national data network proposed by NACRGS in 1967. To this end the subcommittee has established a number of working committees to develop standards for selected geoscience disciplines, including the geology of mineral deposits. The Working Committee on Mineral Deposits Data[1], presently chaired by Dr. P.G. Sutterlin, University of Western Ontario, is responsible for this report and, although authored by an individual member, it has received the endorsation of all Working Committee members.

The location standards recommended herein form part of a larger set of minimum standards to be proposed by the Working Committee with respect to the geological description of mineral deposits in Canada. However, because of the wide applicability and fundamental importance of standards dealing with geographic location, these recommendations are being issued separately.

This report is the second in a series of technical reports identified with activities of the Canadian Centre for Geoscience Data. The Subcommittee on Computer Applications is pleased to contribute to this series and to acknowledge the support of the Geological Survey of Canada in offering to publish this report. The recommendations advanced, however, do not necessarily reflect current Survey policy.

Toronto, Canada
3 January 1972

D. A. Sharp, Chairman,
Subcommittee on Computer Applications,
National Advisory Committee on
Research in the Geological Sciences.

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1 P.G. Sutterlin (Chm.) University of Western Ontario; Mrs. K.L. Edmond, Geological Survey of Canada, R.V. Longe, Rio Tinto Exploration Ltd.; A.M. Kelly, Geological Survey of Canada; G.D. Williams, University of Alberta; K.A. Ewing, Mineral Resources Branch; S.A. Ferguson, Ontario Department of Mines and Northern Affairs; A.D. Oliver, Department of Indian Affairs and Northern Development; P. Laznicka, University of Manitoba; C.J. Hodgson, Amax Exploration Inc.

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ABSTRACT

The objective of this study, carried out for the Working Committee on Mineral Deposits Data of the National Advisory Committee on Research in the Geological Sciences, was to define minimum standards for recording data relating to the location of mineral deposits; specifically, what should be recorded, what coordinate system or other means of specifying location should be used, and the precision with which the location should be recorded. Three classes of location were identified: "global", "local", and "legal". Depending on uses made of location data, one or other of these classes are applied in the mineral industry. The distinction between "precision" and "accuracy" is discussed and related to the problem of locating mineral deposits. Finally, a series of twelve conclusions and recommendations is made, which, it is hoped, will assist in standardizing the recording of location data and thereby facilitate the compilation and exchange of mineral deposits data, particularly for those data stored in computer-based systems.

RÉSUMÉ

Le but de la présente étude effectuée pour le Comité d'étude des données sur les gisements de minéraux, du Comité consultatif national sur la recherche dans les sciences géologiques, était d'établir des normes minimales pour l'enregistrement de données relatives à la position de gisements de minéraux; ces normes devaient préciser ce qu'on doit enregistrer, quel système de coordonnées ou quel autre moyen doit-on utiliser pour indiquer la position et avec quelle précision doit-on l'enregistrer. On a établi trois catégories de position: générale, approximative et officielle ("global", "local" et "legal"). L'une ou l'autre de ces catégories est utilisée dans l'industrie minière, selon les usages qu'on fait des données en question. La distinction entre "précision" et "exactitude" est étudiée et rattachée au problème du repérage des gisements de minéraux. Finalement, on exprime une série de douze conclusions et recommandations qui devraient aider à normaliser l'enregistrement des données relatives à la position et faciliter la compilation et l'échange de données sur les gisements, particulièrement des données stockées dans des systèmes informatiques.

RECOMMENDED STANDARDS
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INTRODUCTION

The point of departure for this study was to examine, for the eleven mining jurisdictions of Canada, the statutes relevant to the location of mineral deposits. Office consolidation copies of the various acts were obtained. Upon examination of these, it was immediately apparent that, for good reason, the law concerns itself only with precise legal descriptions of location and is disinterested in measures of location which are referred to any global or national coordinate system. This point will be discussed in greater detail later.

At about this time, a new publication by the Surveys and Mapping Branch, Department of Energy, Mines and Resources, came to the author's attention (Thompson, 1971). This excellent report was prepared for the Canadian Council on Cadastral Surveys and the National Advisory Committee on Control Surveys and Mapping. It deals with claiming and surveying procedures in relation to mineral properties and contains a summary of current practices.

It had been intended, after examining the statutes, to survey actual current practice in each jurisdiction. However, the realization that the legislation does not deal with the problem in a way which is particularly meaningful to mineral deposits files, the survey of practices in the report cited above and the writer's own (admittedly spotty) knowledge of what is done led him, after a discussion with C.F. Burk, Jr., Canadian Centre for Geoscience Data, to abandon this step. Instead, a set of specific objectives relating to the problem were defined and the balance of the work was aimed at achieving these.

Acknowledgments

Originally, K.A. Ewing, Mineral Resources Branch, Department of Energy, Mines and Resources, was to have been a co-author of this report. He has requested that he not be shown as such, since he was unable, due to the demands of his regular work, to make what he felt was a sufficient contribution to the task. However, he did, in fact, make a significant contribution, which is gratefully acknowledged.

Special thanks are also due to L.M. Sebert and Don W. Thompson, Surveys and Mapping Branch, Department of Energy, Mines and Resources, for helpful information, advice and criticism.

OBJECTIVES

To define minimum standards for the recording of data relating to the location of mineral deposits. Specifically, to make recommendations on:

1. What should be recorded,
2. What coordinate system or other means of specifying location should be used, and
3. The precision with which the location should be recorded.

Original manuscript submitted: 27 October 1971.
Final version approved for publication: 22 December 1971.

FACTORS TO BE CONSIDERED

Some of the relevant factors have been discussed in detail in a previous publication of the National Advisory Committee (Brisbin and Ediger, 1967). These will be mentioned here, but only those for which the writer's views differ substantially from those expressed in the report cited will be elaborated upon.

The Concept of "Location"

In this study, "location" refers to a pair of numerical parameters (or three, if one considers depth). Consequently, we are considering what a physicist would call "displacement", not the conventional idea of location. In this sense, only points can be located. An area is then defined by stating the coordinates of a set of points, lines joining which will enclose the area of interest. In the case of a volume, the connecting lines define surfaces which enclose the volume.

For the present purposes, it is useful to define three classes of location, which will be referred to as "global", "local" and "legal" locations.

"Global" location is defined as the coordinates of a point with respect to a theoretical frame of reference, or graticule, assumed fixed to the earth's surface. For purposes of determining these coordinates, the earth is assumed to be an ellipsoid of revolution, generated by using one of the several sets of values for the length of the major and minor axes derived from measurements made over the past century and a half. The one most commonly used in North America is called the Clarke (1866) spheroid. The coordinate systems used are usually geodetic latitude and longitude or the Universal Transverse Mercator (UTM) grid. (Geodetic latitudes are defined as the angle between a normal to the spheroid and the plane of the equator. These lines, in general, do not pass through the earth's centre.) Global locations are made without reference to a particular map or physical control points.

"Local" locations are also often given in geodetic or UTM coordinates. They differ from global coordinates in that they are measured from a specific map and their frame of reference is either the "neat line" (the inner margin, on Canadian maps) or the graticule printed on the map. The distinction between them and global location is primarily one of accuracy and precision. As will be seen, for large-scale maps local locations can be determined with high precision with respect to a specific map, but may be inaccurate in a global sense.

"Legal" locations are usually expressed in terms of distances and bearings referred to a local control point such as a survey monument or distinctive topographic feature, or, in surveyed locations, by reference to lot and concession lines. The general region in which the points lie may be identified by giving approximate latitudes and longitudes or the names of legal entities (townships, etc.) containing the points.

These three types of locations arise as a result of (a) the differing requirements of those who record or report the data and (b) the differing precision and accuracy of various surveying methods.

Points to be Located

The report cited by Brisbin and Ediger (1967, p. 56) defines a mineral deposit as follows:

> "A body of rock containing, or thought to contain, ore minerals or potential ore minerals."

Although some disagreement with this definition has been expressed by members of the Mineral Deposits Working Committee, it was decided to continue its use as a working definition, at least pro tem. The writer interprets it to include fossil fuels, since they are "minerals" in the economic sense.

In this context, the objects to be "located" can be subdivided into a small number of classes:

A. Objects whose physical size is sufficiently small with respect to the precision of the measurements involved that they can be considered points. Examples are survey monuments, claim stakes, well-heads and small mineral "showings".

B. Objects of regular geometric shape oriented with the coordinate system in use. National Topographic System (NTS) quadrangles, UTM grid squares, legal entities such as townships, lot and concession lines, are good examples. One point is usually enough to define these, if their dimensions are known.

C. Objects of regular geometric shape, not oriented to the coordinate system. Examples are lineaments such as veins (or straight segments thereof), claims, or arbitrarily defined "blocks" of ore in an open-pit mine. Two or three points are usually enough to define them, when their dimensions and orientation are known.

D. Objects of irregular shape. Ore-bodies and oil or gas pools, or their surface projections are examples. In general, many points are needed to define them precisely.

Uses of Location Data

The uses of location data can also be grouped, this time into three classes. These do not have an exact one-to-one relationship with the classes of data described above, but the overlap is slight. The uses are:

A. To locate a point on the earth's surface as a destination. For marine and air navigation, global coordinates are needed. In earth science in general, and for mineral deposits in particular, local coordinates usually suffice. The chief exceptions to this rule are geodetic and certain types of geophysical surveys, which are tied in to a continental or worldwide network of control points. Excluding these, if one has a topographic map of appropriate scale and has located the point of interest on it, the position on the ground can usually be found with adequate accuracy by reference to topographic features in its immediate neighbourhood.

B. To locate points on a map (including the drawing of maps). For these applications, accuracy is usually limited by the errors inherent in the map production process rather than those related to surveying, except for large-scale maps (scale greater than 1:50,000). At these larger scales, the uncertainty of global location is greater than that of local location (see next section); however, for applications requiring such large-scale maps, the question of global accuracy is usually less relevant than that of local accuracy, so that a conflict is unlikely.

C. To fulfill a legal requirement or establish a legal right. In this case, location relative to a global or local frame of reference is less important (except for offshore locations) than precision of description with respect to established physical monuments or well-defined topographic features. As will be shown, the maximum attainable accuracy of global or local coordinates is usually insufficient for legal purposes. As a result, most jurisdictions do not require the recording of these data. (This is regrettable, since the incremental effort required to record such data is small and the recording of them would make the large files compiled for legal purposes very useful for scientific and technical applications.) In the case of those jurisdictions which use a grid system for the establishment of legal mining rights and in the case of offshore locations, it is self-evident that global or local coordinates must be used. However, as will be seen, this could lead to legal complications because of the accuracy problem mentioned.

Precision and Accuracy

The common dictionary definitions and ordinary usage of these terms tend to make them synonymous. For present purposes, they should be used in their scientific senses, which makes a distinction between them. Essentially, this is that precision refers to the exactness of a measurement, that is, the number of significant digits recorded; accuracy pertains to the relative error of the measurement, referred to the (unknown) "true" value. To be useful for scientific purposes, measurements need not always be precise; they must, however, be accurate or, at least, the range of error must be known.

This point is stressed as a result of the recommendation of the Subcommittee on Geographic Coordinates and Reference Numbering, given in Brisbin and Ediger (1967, p. 42), that:

> ". . . geographic location be defined by latitude and longitude in degrees to five decimal places. . ."

The fifth decimal place (0.00001°) of latitude corresponds to a distance of approximately 1.1 metres; in longitude it varies from 1.1 metres at the equator to zero at the poles. As will be seen, this precision (and the accuracy it implies) is unattainable for global location with present technology and, except for maps of very large scale, is impractical for local locations. For legal locations, greater precision is usually required; however, as noted, geographic coordinates are not generally used for these.

The method and precision of recording location will then depend on the class of location recorded and the accuracy attainable in practice.

Global locations are determined by reference to continental nets of control stations, using high-precision surveying techniques involving electronic distance-measuring equipment, theodolites, triangulation using satellites, etc. (These nets will eventually be worldwide). The origin of the North American network is a monument on Meade's Ranch, Kansas. Until recently, the locations of the other control points in the network were determined by ground geodetic surveys starting from this point; the overall accuracy of these surveys was 1:100,000. This leads to uncertainties of position which increase in direct proportion to the distance of a point from Meade's Ranch. However, for several years now, a project has been in progress to check and adjust the network by means of very precise triangulation methods, involving the use of earth satellites. For Canada, the measurements will be completed in 1972, with the adjustments to the network expected to be finished by 1980 (C.D. MacLennan, pers. comm.). As a result of it, the uncertainty of location of all the primary control points in Canada will be less than 15 metres and will be independent of their location (L.M. Sebert, pers. comm.).

The topographic and photogrammetric surveys carried out for purposes of drawing maps are, of course, somewhat less precise. The magnitude of the uncertainties introduced by these depends on a variety of factors such as distance from primary control points, type of survey, etc.

In general, a conservative estimate of the minimum attainable uncertainty for any distinctive topographic feature would be 25 metres.[1]

Local locations are measured by identifying topographic features on a map or aerial photograph, then using the neat line or overprinted graticule of the map to determine the coordinates. The Surveys and Mapping Branch of the Department of Energy, Mines and Resources conforms to the NATO standards system for planimetric accuracy (L.M. Sebert, pers. comm.; Anon.-a). The standard says, in effect, that the criteria for planimetric accuracy at scales of 1:600,000 and larger are such that 90 per cent of well-defined features (except those unavoidably distorted by exaggerated symbolization) will have maximum uncertainties of location referred to the graticule printed on the map, as shown in Table I.[2]

TABLE I

Accuracy Ratings-Topographic Maps

Rating	Limits of error in millimetres
A	0.5
B	1.0
C	greater than 1.0
D	not known

The limits of error given in Table I are for measurements made on the map and allow for all errors inherent in the map production process and for paper shrinkage. These numbers must, of course, be multiplied by the reciprocal of the map scale in order to convert them to lengths on the ground.

The largest scale for which complete topographic map coverage of Canada exists at present is 1:250,000. About one-third of the country has been mapped at 1:50,000; production of maps at this scale is proceeding at the rate of about 300 sheets per year, and current plans call for complete coverage by the year 2000, at the latest. By that time, all Canadian topographic maps should be rated class A.

At present, the stated policy of the Branch is to provide larger scale maps only for urban areas or areas considered important for industrial or military purposes.

All 1:250,000 and larger scale maps have UTM grids printed on them.

For our purposes, then, we can assume that the largest scale generally available is 1:50,000, and that for the present, a significant number of data will be derived from 1:250,000 scale maps. An uncertainty of 0.5 mm. on the map is equivalent to 25 m. or 125 m. on the ground at these respective scales. These uncertainties, of course, are the best attainable. In practice, a man in the field who may be wet, cold, tired and hungry, using a blunt pencil and home-made romer, in failing light and in country with few identifiable landmarks, is not likely to achieve this precision consistently.

Conversations with a number of people who have relevant experience indicate that in the worst case (i.e., using a 1:250,000 map under the conditions mentioned above), a maximum uncertainty of 250 metres, referred to the map graticule, should be realizable in practice. By using aerial photographs (for which complete coverage of the country is available at scales of 1:63,360 and larger), and larger scale maps, under office conditions, this uncertainty can be reduced to about 25 metres.

Clearly, there are two separate situations here. For scales of 1:25,000 and larger, the apparent uncertainty in a location derived from a map (12.5 metres or less) is less than the real uncertainty in the location

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[1] This is the figure that will be attainable by the end of the present decade. In some areas at present, uncertainties can range up to 100 metres.
[2] This is a summary of part of the document cited.

of geodetic control points (15 metres or more). To quote the apparent uncertainty would be misleading, unless it is done in a manner which clearly indicates that the location is a local one, i.e., it refers to the graticule of a particular map.

For scales of 1:50,000 or smaller, the apparent uncertainties in a location derived from a map are sometimes equal to, but more often greater than, those attainable by a geodetic survey. In this case, the distinction between local and global coordinates disappears and it is unnecessary to quote the specific map from which the location has been derived.

Legal locations are more difficult to discuss in a meaningful way insofar as scientific and technological applications are concerned. However, since a review of the appropriate statutes indicates that these are the only kind recognized in law, they assume an importance disproportionate to their usefulness for other applications.

As might be expected, the law concerns itself primarily with precision, paying little attention to accuracy. Knowing the position of a point on a boundary line, with high precision relative to a nearby monument, is important, for example, in settling boundary disputes. The latitude and longitude of the same point, or even its precise position within a legal subdivision such as a township is, for legal purposes, usually irrelevant.

Yet, much archival data which could be useful for scientific purposes are recorded in this form. At present, the best that can be done if one wishes to use these data for other than legal purposes, is to attempt to locate the points of interest on a topographic map and then measure their coordinates.

Recording of geographic coordinates at the time of recording the legal data might prove very useful for administrative purposes; automated plotting of claim maps (in the preparation of which there is a large backlog of work in many jurisdictions) is the best example which comes to mind.

Systems of Notation

This factor has been discussed adequately in Brisbin and Ediger (1967, p. 87-88). In practice, we need only concern ourselves with two systems, geographic (latitudes and longitudes) and the UTM system. Using available tables or computer programs, coordinates expressed in either of these systems can readily be converted to the other. The following comparison between the systems reveals all the differences relevant to the objectives of this study:

A. The use of the UTM system for non-military purposes is fairly recent and many people are unfamiliar with it. Most people are familiar with geographic coordinates.

B. All Canadian topographic maps of scales 1:250,000 and larger now have the UTM grid overprinted on them, as well as geographic coordinates on the margins. The 1:250,000 series also has partial geographic graticules in the form of small crosses indicating the intersection of major meridians and parallels of latitude.

C. Geological maps show only geographic coordinates, as do topographic maps at scales smaller than 1:250,000.

D. The UTM system is discontinuous, being organized into 60 six-degree zones; the geographic system is continuous.

E. The UTM system is metric and is consistent with the worldwide trend towards use of the metric system. The user, however, does not have to be aware of this. The units in which the coordinates are measured are essentially irrelevant to him since it is a rectilinear system.

F. When measuring positions on a topographic map, it is much easier to obtain precise and accurate results with the UTM system than with the geographic. If necessary, an adequate romer can be made quickly using a piece of paper or cardboard and a pencil. This is not possible for the geographic system, since it is non-linear.

G. The uncertainty of positions recorded in geographic coordinates is misleading, because of its non-linearity. A precision of, say, .01° implies an uncertainty in longitude which varies from approximately 1 km. at the equator to zero at the poles.

Compatibility

In view of the ease of conversion, files using either system would be compatible. However, a measure of the reliability (i.e., precision) of the data is necessary to ensure this.

CONCLUSIONS AND RECOMMENDATIONS

1. The advantages of using the UTM system outweigh those of geographic coordinates, especially at the time of determining and recording the data. However, the system is not yet widely used in the earth sciences, nor are UTM grids printed on geological maps. Accordingly, it is recommended that, for the present, either system be used, so long as a particular file is internally consistent. In the long term, the UTM system should be adopted for all files. If the geographic system is used, four decimal places are adequate for most purposes (except _vide_ recommendation 5, below).

2. Tables (Anon.-b, 1958) are available for the conversion of UTM coordinates to geographic coordinates and vice versa. If many data are to be converted, however, the task is tedious. Accordingly, it is recommended that the Canadian Centre for Geoscience Data acquire and distribute on demand appropriate computer programs for making conversions.

3. A larger proportion of potential and known deposits are in areas for which the largest scale of topographic map available is 1:250,000. This situation will continue for some years. Accordingly, it is recommended that in current and future field work _all_ locations be reported to at least a precision of 250 metres. (This recommendation is based on the assumption that any point in Canada is locatable to at least this precision.)

4. There are many valuable old reports in which the location data are very imprecise. (The author recently came across one in which the location was given as "a three-hour horseback ride northwest of..."; needless to say, this report will not be cited.) Also, some locations will be given to a higher precision than 250 metres. Accordingly, it is recommended that the uncertainty of location, in _linear_ units (i.e. _not_ degrees, minutes or seconds), together with the units, be recorded. "Uncertainty", in this sense, is the radius of the circle which, if centred on the apparent location, will almost certainly contain the point of interest.

5. If an individual file is to contain locations with higher precision than 250 metres, the specific map and its date of publication should be recorded as well.

6. Areas whose dimensions are less than or equal to twice the uncertainty of location can be treated as points. For example, a 1500-by 1500-foot claim is approximately enclosed by a circle of 250 metres radius. It is, to this precision, a point. Many mineral deposits (excluding oil and gas pools and certain kinds of sedimentary deposits such as coal) will be smaller than this insofar as their surface projections are concerned. Larger features will usually (except for veins) be of irregular shape. Therefore, it is recommended that the prime location recorded should normally be the "centroid" of the area. In most cases, this can be located approximately by eye with adequate accuracy.

7. To compensate for differing precisions and scale, the identification record should indicate what the location data refer to, i.e., well-head, claim, centroid of mineralized zone, head-frame, etc.
8. For areas which are large compared to the uncertainty of location, a short description indicating the approximate boundaries of the area should be recorded.
9. The NTS sheet number of the 1:50,000 sheet containing the point should be recorded.
10. The legal jurisdiction containing the point should be recorded, at least at the level of province or territory.
11. In view of the Committee's desire to keep the standards simple and small in number, and considering the comments on the subject in Brisbin and Ediger (1967), it is recommended that only planimetric locations be required for the standard. When elevations or depths are recorded, they should, for the present, be considered additional data and not as a part of the location.
12. To facilitate the adoption of the UTM system, it is suggested that the Geological Survey of Canada and other map-producing agencies overprint UTM grids on all future geological maps published at scales of 1:250,000 and larger.

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