



Designation: E 901 – 82 (Reapproved 1995)^{ε1}

Standard Classification System for Uranium Resources¹

This standard is issued under the fixed designation E 901; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

^{ε1} NOTE—Keywords were added editorially in June 1995.

INTRODUCTION

Background

The problems of estimating the reserves of a mineral on a property or the extractive resources yet to be found in a region have vexed the mineral professions for over one hundred years. How to classify various types of estimates and how to define the terms used have not been solved. The problems date from at least as far back as 1909, when Herbert Hoover agonized over them in his *Principles of Mining*.

In uranium resource evaluation, there can be found all of the traditional differences between advocates of various points of view relative to the problems. In addition, inconsistencies exist among the three U.S. government groups (Department of Energy and the Department of Interior's Bureau of Mines and Geological Survey) active in the appraisal of uranium resources as well as among the various practitioners of the private sector and between them and the government groups. The terms and classifications that have evolved are a reflection of the needs or perspectives of the user or the mineral professions involved.

Therefore, those who are seeking current information about uranium resources in general, or about the recoverable reserves of a specific property or properties, find a multiplicity of data and terminology. Perhaps most disconcerting is frequent disparity in the quality and character of the data expressed in identical terms. Information issued by the U.S. Department of Energy employs terminology and classifications according to a system that has evolved over many years, starting with the Atomic Energy Commission. The U.S. Department of Interior uses a different terminology and classification for the various mineral commodities under study by the agencies within that Department. The Steering Group on Uranium Resources of the International Atomic Energy Agency and the Nuclear Energy Agency has developed still another approach seeking to accommodate a diversity of practices by many nations. If mineral resource professionals are to be consistent in categorizing the uranium resource data they produce, then it is important to standardize practices.

ASTM Task Group E10.14.01

ASTM was approached by the U.S. Department of the Interior in late 1976 to undertake development of standards required in the area of raw material resources. Arising from the general interest in the President's National Energy Plan of April 1977, ASTM decided to undertake such an effort for domestic uranium resources. Task Group E10.10.38 was constituted and assigned the task of identifying the need for standards in the areas of: (1) definitions and classification for Uranium Resources, (2) calibration of bore hole logging devices, and (3) airborne sensors. Scope of work for items No. 2 and No. 3 was prepared and the standards writing activity was assigned to ASTM Committee C-26. Subcommittee E10.14 on Uranium Resource Evaluation was formed to undertake the planning/development of needed standards in the area of Uranium Resource Evaluation. Task Group E10.14.01 continued the work begun by E10.10.38 and as a result, developed a Standard Classification System for Uranium Resources.

Approach to Classification

The task group decided to avoid adopting any previously established system, but rather to begin with the examination of concepts and fundamentals of uranium resource estimation. From this, grew the recognition that there are two basic perspectives which are not always compatible or readily related. There is the perspective of the mineral engineer who is trying to estimate and describe the

quantities of uranium that may be recoverable from a specific uranium deposit at various costs. Usually, this will tend toward conservative judgments made about the quantities that might be found and recovered beyond present workings. This contrasts sharply with a geologist's regional appraisal across the entire spectrum, from densely drilled prospects to totally unknown territory.

It was the decision of the task group to deal first with the problems of a resource classification system that would encompass the total availability of primary uranium resources above a specified minimum concentration and deposit size. This involved a conceptual approach somewhat similar to that of the Department of Interior published in U.S. Geological Survey Circular 831. However, in so doing the task group was mindful of the fact that it would eventually need to provide a classification system that would include standards for the estimates that fall within each category. This next stage has been undertaken by Task Group E10.14.02 on Uranium Resource Classification Estimation Criteria.

ASTM Task Group E10.14.02

Using the classification framework of the draft standard developed by Task Group E10.14.01, Task Group E10.14.02 is formulated) level of knowledge, including mineralization continuity, and (2) economic producibility. Establishment of the degree of certainty in mineralization continuity will require the development and application of statistical and other mathematical and geologic considerations. Estimation of the economic or noneconomic producibility of a resource will require considerations such as: (1) costs, prices, and cash flows, and (2) the interrelationships of grade, cost, resource depth beneath the surface, and other factors.

While the approach of E10.14.02 is to consider independently the two components, mineralization continuity and economic producibility, it is recognized that a relationship exists between the two components. The relationship is brought into focus by the necessity of involving the disciplines of geology, mining engineering, geostatistics, and mineral economics in the work of E10.14.02.

1. Scope

1.1 This classification system covers all naturally occurring uranium-bearing materials and is based on level of geologic knowledge and economic producibility of the resource at a given time.

1.2 Assessments of uranium resources are made for two purposes: (1) to provide aggregate information on the resources of a region or country and (2) to provide information needed for decisions concerning the resources of specific properties or deposits.

1.3 For regional appraisals, broad categories of uranium resources defined in general terms are the most useful.

1.4 For specific consideration of an individual property or to establish the availability of producible resources for commercial purposes, the terms and definitions used require a narrow construction and place emphasis on reliability and the quantification of mineral values in known deposits.

2. Referenced Documents

2.1 *ASTM Standards:*

E 583 Practice for Systematizing the Development of (ASTM) Voluntary Consensus Standards for the Solution of Nuclear and Other Complex Problems²

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *uranium resources*—quantities of uranium in naturally occurring uranium bearing materials on or in the earth's crust,

in such form and amount that economic extraction of uranium is currently or potentially feasible, irrespective of legal, regulatory, environmental, political, or other considerations. Unless otherwise justified in particular situations, the uranium concentration of naturally occurring materials must be equal to or greater than 0.01 % U_3O_8 (100 ppm) to be included in a resource. Quantities of uranium found in processed or manufactured materials are not included in the resource categories defined in this classification system.

3.1.2 *uranium occurrence*—a naturally occurring anomalous concentration of uranium which can be demonstrated to exist.

3.1.3 *uranium deposit*—a volume of naturally occurring uranium bearing material represented by occurrences either with continuity of mineralization between them, or a systematic pattern of recurring mineralization. Continuity or systematic recurrence of mineralization must be based on the geologic character of the occurrences and must be consistent with the distribution of uranium bearing minerals and geologic character of similar known deposits. The volume of rock constituting the uranium deposit must contain at least one ton of U_3O_8 .

3.1.4 *by-product uranium*—that material economically available only through incidental recovery with other products and is not included in this classification system. Such material can be accounted for separately, provided the economic conditions for its producibility are specified.

4. Basis of Classification

4.1 Classification of a resource is based on (1) the level of knowledge and (2) the economic producibility of the resource at a given time. The level of knowledge determines the degree of reliability in establishing the size, shape, depth, distribution, and mineral content of the resource. Economic producibility is based on existing technology and on costs and prices specified

¹ This classification system is under the jurisdiction of ASTM Committee E10 on Nuclear Technology and Applications and is the direct responsibility of Subcommittee E10.93 on Editorial.

Current edition approved Oct. 29, 1982. Published April 1983.

² *Annual Book of ASTM Standards*, Vol 12.02.

		Discovered			Undiscovered or Unsubstantiated	Undiscovered
		Continuity Virtually Assured	Continuity Assumed	Presence of Deposit	Demonstrated Favorability Known Occurrences	Favorable Geologic Environment
		1	2	3	4	5
Economic	A					
Uneconomic	B					
Undetermined	C					
Totals						

NOTE 1—Decreasing Level of Knowledge

FIG. 1 Classification System for Uranium Resources—In-Place

at the time of determination. See Fig. 1 for a diagram of the classification system.

4.2 Resource categories are formed by combining the identifiers used to define the different levels of knowledge and economic producibility.

4.3 Alphanumeric identifiers are used rather than words in order to avoid confusion with existing terms, definitions, and classifications. This approach has been in increasing favor in recent years, as evidenced by work in USSR, Canada, and the United Nations.

5. Classification by Level of Knowledge

5.1 *Class 1 Resources*—Those in-place quantities of uranium in known deposits computed from the results of sampling of outcrops, trenches, workings, or drill holes, or combination thereof. The sites for inspection, sampling, and measurement are so spaced and the geological character is so well defined that size, shape, depth, distribution, and mineral content are well established. Continuity of mineralization between sample points is considered as virtually certain.³

5.2 *Class 2 Resources*—Those in-place quantities of uranium in known deposits, estimated from types of information similar to those identified for Class 1 resources, but with wider spacing of the sites for inspection, sampling, and measurement. Continuity of mineralization between sample points can be assumed, but with less certainty.³

5.3 *Class 3 Resources*—Those in-place quantities of uranium for which available data, such as from drill holes and outcrops, confirm the presence of a deposit or an extension of a known deposit, but the data are inadequate to satisfy the mineral continuity criteria for Class 2 resources.

5.4 *Class 4 Resources*—Those undiscovered or unsubstantiated in-place quantities of uranium that lie within geologic environments of *demonstrated favorability*.⁴ Uranium occurrences are known, but data are inadequate to establish the physical existence of a deposit or an extension of a known deposit. Resource estimates are based on extrapolation of

geologic characteristics of nearby deposits, or on comparison with areas of known deposits that exhibit similar geologic characteristics.

5.5 *Class 5 Resources*—Those undiscovered in-place quantities of uranium that may exist in geologic environments, the characteristics of which indicate a potential for uranium deposits but do not meet the criteria for *demonstrated favorability* of Class 4 resources. There are few, if any, known occurrences of uranium. Estimates are based primarily on geologic analogy.

6. Classification by Economic Producibility

6.1 *Type A Resources*— Those in-place quantities of uranium estimated to be economical at the time of classification under specified prices or costs or under equivalent physical criteria.

6.2 *Type B Resources*— Those in-place quantities of uranium estimated to be uneconomical at the time of classification, but which would be economical under different but specified prices or costs or under equivalent physical criteria.

6.3 *Type C Resources*— Those in-place quantities of uranium for which an economical classification has not been determined.

6.4 *Category r Resources*—That portion of the in-place quantities of uranium estimated to be recoverable by mining, disregarding any losses due to processing, under specified prices or costs. See Fig. 2 for an example. The use of the term

A	1
	1Ar Recoverable
	1A Minus 1Ar Not Recoverable

FIG. 2 Example of a Category r Resource

“reserves” is restricted to 1Ar and 2Ar resources.

7. Significance

7.1 All naturally occurring uranium-bearing materials above a specified concentration can be classified. At the present time the specified concentration is 0.01 % U_3O_8 (100 ppm).

7.2 For any assessment, a quantity of uranium can be classified into only one class and type.

7.3 Quantities in different classes and types may be summed as appropriate. For example, the sum of the quantities of

³ Criteria for degrees of certainty are being developed by ASTM Task Group E10.14.02.

⁴ An environment of “demonstrated favorability” must include the presence in the same geologic setting of known deposits which in aggregate contain at least 10 tons (20 000 lb) of U_3O_8 as evidenced by any combination of past production and present Class 1, 2, or 3 resources. The relationship of the resource under consideration to known deposits must be consistent with the spatial distribution and character of known deposits in that geologic setting.

uranium in Types A, B, and C resources constitutes a total of uranium resources within a given class. However, the sums of various classes (1, 2, 3, 4, 5) should be used with caution because of the different level of knowledge that distinguishes each class.

7.4 Category r materials are part of their respective in-place category resources. For example, as indicated in Fig. 2, 1Ar is part of 1A.

7.5 Classes and types within the present classification system may be further subdivided, provided the new subdivisions are consistent with the existing system.

7.6 Quantities of uranium resources may be reclassified or retyped over a period of time. Reclassified quantities will generally move from Class 5 toward Class 1. This classification system can be used to reassess uranium resources in the

light of new geologic knowledge, progress in science and technology, and changes in economic conditions.

8. Keywords

8.1 assessment of ore deposits; classification system for mineral resources; classification of uranium resources; economic producibility of ore deposits; estimation of mineral reserves; extractive mineral resources; geological classification system; mineral resources classification; mining terminology; nuclear fuel availability; ore deposit quantification; producibility of mineral resources; quantification of mineral deposits; recoverability of mineral reserves; regional resources of minerals; standardization of mining terminology; uranium ore-deposit assessment; uranium resource classification system

APPENDIXES

(Nonmandatory Information)

X1. COMPARISON WITH EXISTING CLASSIFICATION SYSTEMS

X1.1 A comparison of the ASTM classification system with those presently used by domestic government agencies is shown in Figs. X1.1 and X1.2. The Department of Interior (DOI) and Department of Energy (DOE) are the two government agencies most closely concerned with resource classifications, the DOI dealing with estimates of all minerals and energy fuels and the DOE dealing chiefly with energy fuels.

DOI Economic Category	Demonstrated		Inferred	Hypothetical	Speculative	DOI
	Measured	Indicated				
Economic	1Ar	2Ar	3Ar	4Ar	5Ar	
Marginally Economic						
Sub-Economic	1Br	2Br	3Br	4Br	5Br	ASTM
	1C	2C	3C	4C	5C	

DOI Demonstrated Reserve Base = 1A + 2A + 1B + 2B + some specified parts of 1C and 2C.

DOI Inferred Reserve Base = 3A + 3B + some specified part of 3C.

Source: Principles of a Resource/Reserve Classification for Minerals, 1980, U.S. Geological Survey Circular 831.

FIG. X1.1 Department of Interior (DOI) Mineral Resource Classification