BUREAU OF INDIAN STANDARDS

Draft Indian Standard

(WC Draft)

Data Content Standard for Geospatial Information

Part 3 Geology

(For comments only)

Last date for Comments – 15th Feb 2025

FOREWORD

(Formal clauses to be added later)

GIS technology is evolving beyond the traditional tool and becoming an integral part of the information infrastructure in many organizations. To fully realize the capability and benefits of geographic information and GIS technology, spatial data needs to be shared and systems need to be interoperable.

Data standardization is essential as it allows data from one source to be easily used with those from another source to create a richer and more useful product. Further, the availability of Data Content Standards at the organization level significantly helps to store, retrieve and manage spatial and non-spatial databases effectively to address emerging challenges. As far as the soil database is concerned, it consists of geo-referenced digital map data and associated tabular attribute data.

Data content standard (DCS) on systematic geological mapping contains a listing of data elements used to store the various themes data and interpretive data associated with the geology. The relationships within the data are explained through Unified Modelling Language (UML) model in order to properly utilize the data as it is intended. In DCS document each theme is considered as a data element.

In the formulation of this standard, considerable assistance has been derived from the Geological Survey of India.

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INTRODUCTION

Standards on Geology are important to facilitate data sharing, increase interoperability and bring a systematization and automation (automated data sharing) into the process of mapping and Geographic Information System (GIS). Many organisations describe and classify their geological data according to their own standards. For interoperability and trans-boundary geological mapping, standards for common classification are necessary.

Geology may be seen as a "reference data theme" as it provides information for several themes such as Mineral resources, Natural Risk Zones, Land-use, Soil and Energy resources. It has a specific relationship with one of the main important natural resources that is water, through groundwater bodies and aquifers. Interchange, storage and management of geological data require the development of knowledge-based, standardized vocabularies and data structures.

From Geology we get information on

1. Detecting geo-hazards
2. Ensuring the safe disposal of wastes, nuclear wastes, Carbon Capture and Storage
3. Ensuring the safe construction of buildings
4. Providing information for environmental planning
5. Providing information for natural resources exploration
6. Vulnerability underground to contamination
7. Aid in depicting indicators for climate change
8. Providing construction material and minerals

This standard is intended to provide users with geologic-map information in a single, modern standard for the digital cartographic representation of geologic features. The objective in developing this national standard for geologic map symbols, colours, and patterns is to aid in the production of geologic maps and related products, as well as to help provide maps and products that have a consistent appearance.

The purpose is to standardize the different Geological & Geo scientific data set characteristics of geological survey map attribute data developed by the different Geo scientific organizations of India. The different Geo scientific data sets need to be standardized in Indian context by integrating the different data sets of different organizations with different inputs.

Indian Standard

DATA CONTENT STANDARD FOR GEOSPATIAL INFORMATION

PART 3 GEOLOGY

1 SCOPE

This Data Content Standard for Geospatial Information Part 3 Geology provides the following:

a) Common definitions for geo-spatial information on geology to facilitate the effective use and understanding the information availability.

b) Attributes to enhance the data sharing of the geospatial elements.

c) Resolving discrepancies related to use of homonyms and synonyms in the data set of various organization and agencies, which will minimize duplication within and among others.

d) Guidance for geo-spatial professionals on standardized attributes as well as definitions to improve data creation and management.

2 NORMATIVE REFERENCES

The Standards listed in Annex A and Annex B have been referred to while formulating this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreement based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A and Annex B.

3 TERMS AND DEFINITIONS:

For the purposes of this document, the terms and definitions used are given below:

3.1 Aggregation

<UML> Special form of association that specifies a whole-part relationship between the aggregate (whole) and a component part. The symbol for aggregation is shown in Fig.1

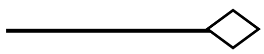


Fig. 1

3.2 Application

Manipulation and processing of data in support of user requirements.

3.3 Application schema

Conceptual schema for data required by one or more applications.

3.4 Association

<UML> Semantic relationship that can occur between typed instances. The symbol for association is shown in Fig. 2. For details refer Sl No r) of Clause 5.1.

Fig. 2

NOTE — Binary association is an association among exactly two classifiers (including the possibility of an association from a classifier to itself).

3.5 Attribute

<UML> Feature within a classifier that describes a range of values that instances of the classifier may hold.

3.6 Cardinality

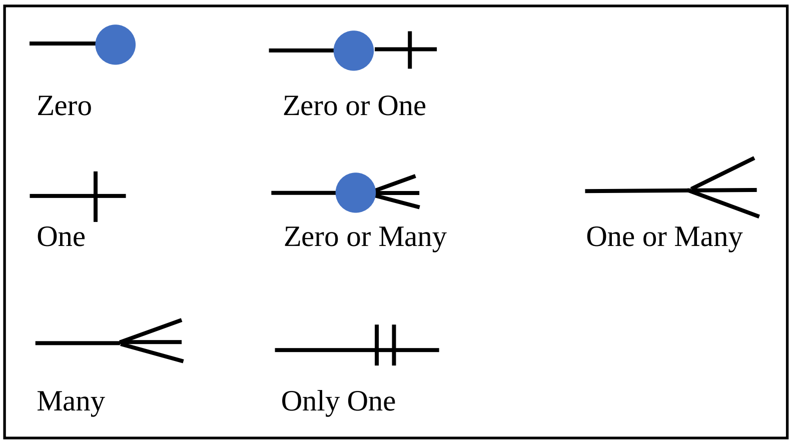
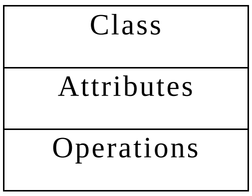


Fig. 3

<UML> Number of elements in a set. The symbols shall be as given in Fig. 3

NOTE — Contrast with multiplicity which is the range of possible cardinalities a set can hold.

3.7 Class



Description of a set of objects that share the same attributes, operations, methods, relationships and semantics. For details refer Sl No. o) of Clause 5.1.

3.8 Classification System

System for assigning objects to classes, in accordance with ISO 19144-1: 01.

NOTE — Classification is an abstract representation of real-world phenomena (i.e. the situation in the field) using classifiers. A classification is a systematic framework with the names of the classes and the definitions used to distinguish them, and the relation between classes. Classification thus necessarily involves definition of class boundaries that must be clear and based upon objective criteria.

3.9 Classifier

<UML> Mechanism that describes behavioural and structural features in any combination.
A classifier is a more general concept in UML that encompasses any element that can have instances. This includes classes, interfaces, components, and other types of elements that may be used to define the structure of a system.

3.10 Component

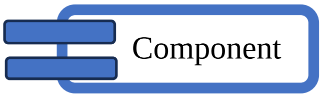


Fig. 4

<UML> Representation of a modular part of a system that encapsulates its contents and whose manifestation is replaceable within its environment. The symbol shall be as given in Fig. 4

3.11 Composition

Fig. 5

<UML> Aggregation where the composite object (whole) has responsibility for the existence and storage of the composed objects (parts). The symbol shall be as given in Fig. 5

3.12 Conceptual model

Model that defines concepts of a universe of discourse.

3.13 Conceptual schema

Formal description of a conceptual model.

3.14 Constraint

<UML> Condition or restriction expressed in natural language text or in a machine-readable language for the purpose of declaring some of the semantics of an element.

3.15 Data type

Specification of a value domain with operations allowed on values in this domain.

NOTE — for example Integer, Real, Boolean, String and Date. Data types include primitive predefined types and user definable types).

3.16 Dependency

Fig. 6

<UML> Relationship that signifies that a single or a set of model elements requires another model element for their specification or implementation. The symbol shall be as given in Fig. 6. For details refer Sl no.q) of 5.1.

NOTE — This means that the complete semantics of the depending elements is either semantically or structurally dependent on the definition of the supplier element(s).

3.17 Feature

<UML> Property of a classifier.

Abstraction of real-world phenomena.

NOTE — A feature may occur as a class or an instance. The full term feature type or feature instance maybe used when only one is meant. In UML the term feature is used for a property, such as operation or attribute which is encapsulated as part of a list within a classifier, such as interface, class or data type.

3.18 Geometry Type

A collection of geographic features with the same geometry type (such as point, line, or polygon), the same attributes, and the same spatial reference.

3.19 Geology Resource Object

Spatial object (point or polygon) where the Geology Resource has been observed.

3.20 Generalization

Fig. 7

<UML> Taxonomic relationship between a more general element and a more specific element of the same element type. The symbol shall be as given in Fig. 7

3.21 Inheritance

Fig. 8

Mechanism by which more specific classifiers incorporate structure and behaviour defined by more general classifiers. The symbol shall be as given in Fig. 8

3.22 Instance

<UML> Individual entity having its own value and possibly its own identity.

NOTE — A classifier specifies the form and behaviour of a set of instances with similar properties.

3.23 Interface

<UML> Classifier that represents a declaration of a set of coherent public <UML> features and obligations.

3.24 Legend

Application of a classification in a specific area using a defined mapping scale and specific data set

NOTE — [UNFAO LCCS: 005]. A legend is the application of a classification in a specific area using a defined mapping scale and specific data set. Therefore, a legend may contain only a proportion, or subset, of all possible classes of the classification. A legend shall be scale dependent, and source dependent. [*See* ISO 19144-1].

3.25 Metadata

Metadata refers to the information that describes the various components of UML models.

3.26 Metamodel

Model that defines the language for expressing other models.

NOTE — A model is an instance of a metamodel, and a metamodel is an instance of a meta-metamodel.

3.27 Model

Abstraction of some aspects of reality.

3.28 Multiplicity

<UML> Specification of the range of allowable cardinalities that a set may assume.

3.29 Object

Entity with a well-defined boundary and identity that encapsulates state and behaviour.

3.30 Operation

<UML> Behavioural <UML> feature of a classifier that specifies the name, type, parameters and constraints for invoking an associated behaviour.

3.31 Package

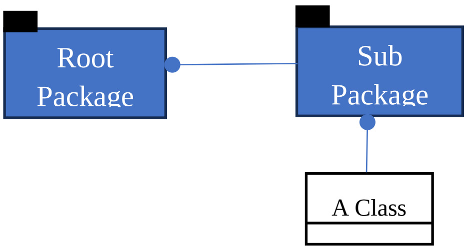


Fig. 9

<UML> General purpose mechanism for organizing elements into groups. The package hierarchy is explained in Fig. 9

3.32 Profile

<UML> Definition of a limited extension to a reference metamodel with the purpose of adapting the metamodel to a specific platform or domain.

3.33 Relationship

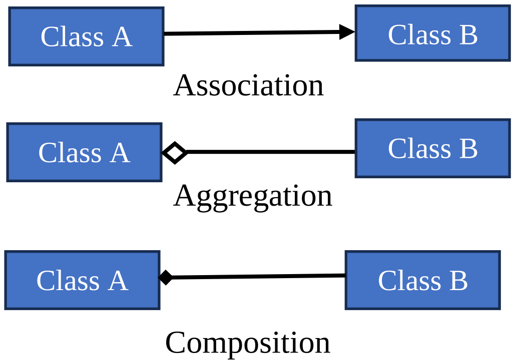


Fig. 10

<UML> Semantic connection among model elements. The relationships shall be depicted as shown in Fig. 10. For details refer SL No p) of 5.1.

3.34 Schema

Formal description of a model.

3.35 Service

Distinct part of the functionality that is provided by an entity through interfaces.

3.36 Stereotype

<UML> Extension of an existing meta class that enables the use of platform or domain specific terminology or notation in place of, or in addition to, the ones used for the extended meta class.

3.37 Tagged value

<UML> Attribute on a stereotype used to extend a model element.

3.38 Type

<UML> Stereotyped class that specifies a domain of objects together with the operations applicable to the objects, without defining the physical implementation of those objects.

3.39 Value domain

Set of accepted values.

4 DATA CONTENT STANDARD FOR GEOLOGY

This Data Content Standard (DCS) on systematic geological mapping provides for a listing of classes that shall be used to store the various themes data and interpretive data associated with the geology. The relationships within the data are explained through Unified Modelling Language (UML) model in order to properly utilise the data as it is intended. In this standard each theme is considered as a data element.

4.1 SURFACE GEOLOGY

The surface geology influences the geology, geomorphology and physiography. In the geology theme the entire country is covered by 1:50K geological mapping, Geomorphological mapping in various scales as different physiographic features and other features as fossil occurrences, archaeological sites and mine quarries in 1:50K scale maps.

Geology defines the structure of the earth on and beneath its surface and the processes that have shaped those geological features. Geology deals with characterization of mineralogical composition of rocks in order to get insight into their history of formation. It provides the evidences for plate tectonics, the evolutionary history of life, and the earth's paleo climates. Geological spatial variation i.e. variation of earth's surface from place to place with different directions and orientations.

4.2 DESCRIPTION OF CLASSES UNDER SURFACE GEOLOGY:

4.2.1 *LITHOLOGY* (*Geometry type-Polygon*)

The lithology of a rock unit is a description of its physical characteristics visible at outcrop, in hand or core samples, or with low magnification microscopy. Physical characteristics include colour, texture, grain size, and composition Lithology refers to either detailed description of these characteristics, or a summary of the gross physical character of a rock as given in **Table 1.**

a) Geology > Geology 50k
b) Coverage - Pan India
c) Projection -WGS 84 Zone 44N
d) Scale: 1: 50K

Table 1 – Lithology Classes
(*Clause* 4.2.1)

Sl. No. (1)	Data Element Name (2)	Short Name (3)	Data Type (4)	Length (5)	Unit of measurement (6)	Maximum Value (7)	Minimum Value (8)	Field Description/Definition (9)
i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require

								a topographic map to show both natural and artificial features. A topographic survey shall typically be based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Topographic maps shall adopt a national grid referencing system.
iii)	age	AGE	Text	40	NIL	NIL	NIL	The geological age is a representation of time based on the rock record of the Earth. It is a system of chronological dating that uses Chrono -stratigraphy (the process of relating strata to time) and geochronology (a scientific branch of geology that aims to determine the age of rocks). It is used primarily by Earth scientists (including geologists, paleontol ogists, geophysicists, geochemists, and paleo-climatologists) to describe the timing and relationships of events in geologic history. The geological time scale has been developed through the study of rock layers and the observation of their relationships and identifying features such as lithologies, paleomagnetic properties, and fossils. The chronostratigraphic divisions are in turn used to define geo chronologic units.
iv)	superGroup	S_GR P	Text	40	NIL	NIL	NIL	A Supergroup is a set of two or more associated groups and/or formations that share certain lithological characteristics. A Supergroup may be made up of different groups in different geographical areas.
v)	groupName	GRP	Text	40	NIL	NIL	NIL	A litho-stratigraphic unit consisting of a series of related formations that have been classified together to form a group. Formations are the fundamental unit of stratigraphy. Groups may sometimes be combined into Supergroups. Groups are useful for showing relationships between formations, and they are also useful for small-scale mapping or for studying the stratigraphy of large regions. Geologists exploring a new area have sometimes defined groups when they believe the strata within the groups may be divided into formations during subsequent investigations of the area. It is possible for only some of the strata making up a group to be divided into formations.

vi)	formation	FRM	Text	40	NIL	NIL	NIL	A geological formation, or simply formation, is a body of rock having a consistent set of physical characteristics (lithology) that distinguishes it from adjacent bodies of rock, and which occupies a particular position in the layers of rock exposed in a geographical region (the stratigraphic column). It is the fundamental unit of litho-stratigraphy, the study of strata or rock layers. A formation must be large enough that it can be mapped at the surface or traced in the subsurface. Formations are otherwise not defined by the thickness of their rock strata, which may vary widely. They are usually, but not universally, tabular in form. They may consist of a single lithology (rock type), or of alternating beds of two or more lithologies, or even a heterogeneous mixture of lithologies, so long as this distinguishes them from adjacent bodies of rock.
vii)	member	MBR	Text	30	NIL	NIL	NIL	In geology, a member is a named lithologically distinct part of a formation. A member need not be mappable at the same scale as a formation. Members are lithologically distinctive where present. The definition and recognition of formations and members allow geologists to correlate geologic strata across wide distances between outcrops and exposures of rock strata
viii)	lithologicalUnit	LITHO	Text	100	NIL	NIL	NIL	The lithology of a rock unit is a description of its physical characteristics visible at outcrop, in hand or core samples, or with low magnification microscopy. Physical characteristics include colour, texture, grain size, and composition Lithology refers to either detailed description of these characteristics, or a summary of the gross physical character of a rock.
ix)	subGroup	SUB_GRP	Text	100	NIL	NIL	NIL	Groups are occasionally divided into subgroups and subgroups are mentioned in international commission on stratigraphy guidelines only in exceptional circumstances.
x)	intrusive	INTR	Text	100	NIL	NIL	NIL	Intrusive rock, is also called plutonic rock. Intrusive rock is formed when magma penetrates existing rock, crystallizes, and solidifies underground to form intrusions, such as batholiths, dikes, sills, laccoliths, and volcanic necks. Igneous rock, formed from the magma, forced into older rocks at depths

								within the Earth's crust, which then slowly solidifies below the Earth's surface, though it may later be exposed by erosion.
xi)	(script)Notation	SCRIPT	Text	55	NIL	NIL	NIL	Abbreviated form of Litho unit
xii)	stratigraphy	STRATI	Text	400	NIL	NIL	NIL	Stratigraphy is a branch of geology concerned with the study of rock layers (strata) and layering (stratification). It is primarily used in the study of sedimentary and layered volcanic rocks. Stratigraphy has three related subfields: litho-stratigraphy (lithologic-stratigraphy), biostratigraphy (biologic stratigraphy), and chrono-stratigraphy (stratigraphy by age).
xiii)	remarks	REMARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.2 *LITHOLOGICAL BOUNDARY (Geometry type- Polygon)*

A lithological boundary refers to a distinct interface or transition between different types of rock or sediment, characterized by variations in their physical and chemical properties. This boundary occurs in various geological settings and is significant in fields such as geology, sedimentology, and stratigraphy. The Lithological Boundary Classes shall be as given in **Table 2.**

Table 2 – Lithological Boundary Classes

(*Clause* 4.2.2)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Maximum Value (7)**	**Minimum Value (8)**	**Field Description/Definition (9)**
i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A

								topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Topographic maps also adopt a national grid referencing system. They contain information about an area like roads, railways, settlements, canals, rivers, etc.
iii)	boundaryType	BND_TY	Text	40	NIL	NIL	NIL	Lithologic boundary refers to the surface that separates rock bodies of different lithologies, or rock type. A contact may be conformable or unconformable depending upon the types of rock, their relative ages and their attitudes. A fault surface may also serve as a contact.
iv)	remarks	REMARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.3 Linear *Oriented Structure (Geometry type-Point)*

Oriented Structure Line elements are from linear structures. The trace of bedding on the cleavage or the trace of cleavage on the bedding constitutes an intersection lineation. Another common type of linear structure is the mineral lineation marked by preferred orientation of elongated grains. The Linear structures shall be referred to with symbol L. The Linear Oriented Structure Classes shall be as given in **Table 3.**

a) Geology > Geology 50k
b) Coverage - Pan India
c) Projection -WGS 84
d) Zone 44N
e) Scale: 1: 50K

Table 3 – Linear Oriented Structure Classes
(*Clause* 4.2.3)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**
i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-

								scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Topographic maps also adopt a national grid referencing system.
iii)	pointType	POIN T_TY	Text	40	NIL	NIL	NIL	Point type included information about Linear Structure (Codelist)
iv)	strike	STRI KE	Double		Degree	360°	0°	The strike is the geographic direction of horizontal line occurring on a planar structure.
v)	plungeAmou nt	PLG_ AMT	Short		Degree	90°	0°	The angle of plunge is the amount of tilt. It is the angle, measured in the vertical plane, that the plunging line makes with the horizontal.
vi)	plungeDirect ion	PLG_ DIR	Double		Degree	360°	0°	Plunge direction of a linear structure is the strike of the vertical plane on which the line is occurring.
vii)	remarks	REM ARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.4 Planar *Oriented Structure (Geometry type- Point)*

These structural elements are from planar structures. The most commonly occurring penetrative planar structures are the stratification or bedding and the cleavage. The trace of bedding on the cleavage or the trace of cleavage on the bedding constitutes an intersection lineation. The planar structures shall be referred as S-planes. The Planar Oriented Structure Classes shall be as given in **Table 4.**

Table 4 – Planar Oriented Structure Classes

(*Clause* 4.2.4)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**
i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Topographic maps also adopt a national grid referencing system.
iii)	pointType	P_TY	Text	40	NIL	NIL	NIL	Point type includes information about Linear Structure (Code list)
iv)	strike	STRIKE	Double	NIL	Degree	360°	0°	The geographic direction of a line created by the intersection of a plane and the horizontal.
v)	dipAmount	DIP_AMT	Short	NIL	Degree	90°	0°	Dip is the angle at which a planar feature and a horizontal plane intersect.
vi)	dipDirection	DIP_DR	Double	NIL	Degree	360°	0°	The dip direction refers to the geographic direction of a horizontal line at a right angle to the strike and towards the downward inclination of the planar structure.

vii)	remarks	REMARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.5 ***Dyke (Geometry type- Line)***

A dyke is an intrusive body (sheet of rock) that intruded in pre-existing rock body. When the intrusion is in between the layers in a layered rock, it is called a sill and not a dyke. It is a type of tabular or sheet intrusion, that either cuts across layers in a planar wall rock structure, or into a layer or unlayered mass of rock. Dykes can be either magmatic or sedimentary in origin. A magmatic dyke is formed when magma (lava) flows into a crack and solidifies as a sheet or tubular intrusion. It can cut through layers of rocks or the contagious rock mass. Clastic or sedimentary dikes form when sediment fills a pre-existing crack in the rock. Dyke shall be defined as per the Data Elements given in **Table 5**.

Table 5 – Dyke Classes
(*Clause* 4.2.5)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Maximum Value (7)**	**Minimum Value (8)**	**Field Description/Definition (9)**
i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation), but historically using a variety of methods. Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Topographic maps also adopt a national grid referencing system.

iii)	dykeType	DYKE_TY	Text	30	NIL	NIL	NIL	Dyke Type (codelist)
iv)	lithology	LITHO	Text	100	NIL	NIL	NIL	The lithology of a rock unit is a description of its physical characteristics visible at outcrop, in hand or core samples, or with low magnification microscopy. Physical characteristics include colour, texture, grain size, and composition. Lithology refers to either detailed description of these characteristics or a summary of the gross physical character of a rock.
v)	remarks	REMARKS	Text	55	NIL	NIL	NIL	Any additional information

4.2.6 *Fold (Geometry type- Line)*

A fold is represented by a curved surface structure or a stack of curved surfaces whose initial curvature has increased by deformation. Since stratification in undeformed sedimentary beds is planar within a short distance, a distinctly curved or wavy stratification surface is commonly described as fold. Cross-stratified beds may show initial curvatures of the fore set laminae. Such initially curved bedding laminae are said to be folded if the initial curvature is perceptibly increased by deformation. Fold shall be defined as per the Data Elements given in **Table 6.**

Table 6 – Fold Classes
(*Clause* 4.2.6)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**
i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Region of GSI from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map

								sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Topographic maps also adopt a national grid referencing system.
iii)	foldType	FOLD_TY	Text	40	NIL	NIL	NIL	Different types of Fold (codelist)
iv)	remarks	REMARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.7 ***Fault (Geometry type- Line)***

A fault is a fracture discontinuity along which the rocks on either side have moved past each other. The attitude of the fault plane is expressed by its dip and strike or by its dip and dip direction. The trace of the fault on the earth's surface is the fault line. If fault is not vertical, the side above the fault plane is called hanging wall and the side below the fault plane is called foot wall. A fault surface may be curved or planar. Fault shall be defined as per the Data Elements given in **Table 7.**

Table 7 – Fault Classes
(*Clause* 4.2.7)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Maximum Value (7)**	**Minimum Value (8)**	**Field Description/Definition (9)**
i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common

								specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodeti c datum. Topographic maps also adopt a national grid referencing system.
iii)	faultType	FAUL T_TY	Text	40	NIL	NIL	NIL	Different types of Fault (code list)
iv)	faultName	FAUL T_NM	Text	50	NIL	NIL	NIL	Name of Fault
v)	remarks	REM ARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.8 ***Shear Zone (Geometry type- Line)***

A shear zone is a planar or curviplanar narrow zone of high deformation which is long length relative to its width (length to width ration greater than 5:1) and which is surrounded by rocks showing a lower state of finite strain.

The term shear zone encompasses both clean-cut fault and ductile shear zone. The Shear zone classes shall be defined as given in Table 8.

Table 8 – Shear zone Classes
(C*lause* 4.2.8)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Lengt h (5)**	**Unit of measureme nt (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**
i)	inputCente rCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series,

								made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geodetic datum. Topographic maps also adopt a national grid referencing system.
iii)	kinematics	KINE	Text	100	NIL	NIL	NIL	Kinematics is a branch of classical mechanics that studies movement. In structural geology, kinematics is the description of the path that rocks took during deformation. Kinematic analysis involves four basic types of change: Translation, Rotation, Strain, and Vorticity. Kinematic analysis is concerned with the direction of movement, which movement is allowable and which is constrained.
iv)	remarks	REMARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.9 ***Morphological Element Line (Geometry type: Line)***

Different types of linear morphological features on earth surface shall be defined as per Data Elements given in **Table 9.**

Table 9 – Morphological line Classes

(*Clause* 4.2.9)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**

i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geo detic datum. Topographic maps also adopt a national grid referencing system.
iii)	morphologyType	MORPH_LINE	Text	100	NIL	NIL	NIL	Different types of linear morphological features on earth surface
iv)	remarks	REMARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.10 ***Morphological Element Polygon (Geometry type-Polygon)***
Different types of polygonal morphological features on earth surface shall be defined as per Data Elements given in **Table 10.**

Table 10 – Morphological Classes
(*Clause* 4.2.10)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**

i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geo detic datum. Topographic maps also adopt a national grid referencing system.
iii)	morphologyType	MORPH_POLY	Text	100	NIL	NIL	NIL	Different types of polygonal morphological features on earth surface
iv)	remarks	REMARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.11 *Fossil Occurrence (Geometry type- Point)*

The location where the fossils are found in earth shall be defined as per Data Elements given in **Table 11.**

Table 11 – Fossil occurrence Classes
(C*lause* 4.2.11)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Length (5)**	**Unit of measurement (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**

i)	inputCenterCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geo detic datum. Topographic maps also adopt a national grid referencing system.
iii)	age	AGE	Text	40	NIL	NIL	NIL	The geological age is a representation of time based on the rock record of Earth. It is a system of chronological dating that uses chrono-stratigraphy (the process of relating strata to time) and geochronology (a scientific branch of geology that aims to determine the age of rocks). It is used primarily by Earth scientists (including geologists, paleontologist s, geophysicists, geochemists, and paleo-climatologists) to describe

								the timing and relationships of events in geologic history. The geological time scale has been developed through the study of rock layers and the observation of their relationships and identifying features such as lithologies, paleomagn etic properties, and fossils. The chrono stratigraphic divisions are in turn used to define geo chronologic units.
iv)	fossilDesc ription	FOSSI L	Text	50	NIL	NIL	NIL	Fossils are the remains or traces of ancient life that have been preserved by natural processes. Examples of fossil include spectacular skeletons, shells, bones, stone imprints of animals or microbes, exoskeletons, objects preserved in amber, petrified wood, coal, hair, oil, and DNA remnants. There are six types of fossils: Body Fossils, Molecular Fossils, Trace Fossils, Carbon Fossils, Impression Fossils and Pseudo fossils.
v)	remarks	REM ARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.12 *Mineralization (Geometry type: Point)*

Mineralization is the deposition of economically viable minerals in the formation of ore bodies or "lodes" by various process. Mineralization process includes chemical alteration, replacement, and enrichment of minerals within igneous, metamorphic, and sedimentary rocks. The categorization of mineralization of the earth shall be defined as per Data Elements given in **Table 12.**

Table 12 – Mineralization Classes
(*Clause* 4.2.12)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Leng th (5)**	**Unit of measure ment (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**
i)	inputCenter Code	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is

								a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geode tic datum. Topographic maps also adopt a national grid referencing system.
iii)	commodity	COM M	Text	40	NIL	NIL	NIL	Mineral commodities refer to solids that must be mined. A mineral commodity is defined as a mineral or substance derived from a mineral at any stage of treatment of that mineral. A concentration of naturally occurring solid, liquid, or gaseous materials in or on the Earth's crust in such form that economic extraction of a commodity is regarded as feasible, either currently or at some future time.
iv)	grade	GRAD E	Text	0	NIL	NIL	NIL	The grade of ore is the concentration of the desired material it contains, which determines whether it is profitable to mine. The grade of minerals could also refer to the classification of minerals based on their

								chemical composition and structure, such as silicates, sulfides, carbonates, etc. The grade of minerals could also mean the quality or purity of minerals, which may vary depending on the source and processing methods. This could affect their physical and chemical properties, such as hardness, colour, lustre etc.
v)	remarks	REM ARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.13 *Mine Quarry (Geometry type- Point)*

A quarry is a type of open-pit mine where rocks, sand, or minerals are extracted from the surface of the Earth. A quarry shall be defined as per the Data Elements given in **Table 13.**

Table 13 Mine Quarry Classes
(*Clause* 4.2.13)

Sl. No (1)	**Data Element Name (2)**	**Short Name (3)**	**Data Type (4)**	**Leng th (5)**	**Unit of measure ment (6)**	**Max. Value (7)**	**Min. Value (8)**	**Field Description/Definition (9)**
i)	inputCenter Code	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as

								well as a standard geodetic framework that defines the map projection, coordinate system, ellipsoid and geo detic datum. Topographic maps also adopt a national grid referencing system.
iii)	status	STAT US	Text	15	NIL	NIL	NIL	Status of Mines
iv)	remarks	REM ARKS	Text	50	NIL	NIL	NIL	Any additional information

4.2.14 *Archaeological Site (Geometry type- Point)*

An archaeological site is a place (or group of physical sites) in which evidence of past activity is preserved. It shall be defined as per Data Elements given in **Table 14.**

Table 14 Archaeological site classes
(*Clause* 4.2.14)

	Data Element Name (1)	**Short Name (2)**	**Data Type (3)**	**Leng th (4)**	**Unit of measurem ent (5)**	**Max. Value (6)**	**Min. Value (7)**	**Field Description/Definition (8)**
i)	inputCent erCode	ICC	Text	3	NIL	NIL	NIL	Organization from where data is being entered
ii)	toposheet	TOPO	Text	5	NIL	NIL	NIL	A topographic map or topographic sheet is a type of map characterized by large-scale detail and quantitative representation of relief features, usually using contour lines (connecting points of equal elevation). Traditional definitions require a topographic map to show both natural and artificial features. A topographic survey is typically based upon a systematic observation and published as a map series, made up of two or more map sheets that combine to form the whole map. A topographic map series uses a common specification that includes the range of cartographic symbols employed, as well as a standard geodetic framework that

								defines the map projection, coordinate system, ellipsoid and geo detic datum. Topographic maps also adopt a national grid referencing system.
iii)	descriptio n	DESC	Text	50	NIL	NIL	NIL	Description of Archaeological Site
iv)	remarks	REM ARKS	Text	50	NIL	NIL	NIL	Any additional information

5. UML (UNIFIED MODELLING LANGUAGE):

The data model is represented by UML (Unified Modelling Language) diagrams. UML is a standard language for specifying, visualizing, constructing, and documenting the artefacts of software and non-software systems. UML helps to communicate, explore potential designs, and validate the architectural design of the system. It is possible to model any kind of application, both specifically and independently of a target platform by using UML.

5.1 NARRATIVE DESCRIPTION AND UML OVERVIEW

a) Efficient data interchange over the Web requires capturing and translating the traditional vocabulary and non- standard data structures into precise and structured, domain-specific markup languages. These standard languages allow us to give precise definition and meaning to geological terms, and assigns syntax, data structure to each scientific concept. The languages minimize the loss of information in transit from one source to another, and allow efficient sharing, storage, and management of information.

b) Unified Modelling Language (UML) shall be used as a design aid for capturing the geological concepts and their properties. The UML model may then be converted to the GML conformant GeoSciML. [Refer IS 16626: 2017 and IS 16626 (Part 2): 2018 for GML]

c) Concepts modelled and designed with the UML, shall be mapped into XML Schema Definition (XSD) to compose modular markup languages for each discipline.

d) The challenges are mainly due to the lack of data standards in these fields to support integration of complex data structures.

e) Definition and integration of the metadata that describe the format, constraints, structures, and rules for the scientific data, are necessary for successful sharing, storage, and management of data.

f) A discipline-specific, scientific markup language reflects the syntax and structure of the concepts of the knowledge base of the discipline, and standardizes the exchange, storage, and retrieval of data in that discipline.

g) A domain-specific markup language attaches context to the value of data and allows data to transmit information (meaning), making it more useful and less prone to loss or corruption.

h) Knowledge management includes all the continuous ways in which the knowledge in a specific field or domain (e.g., sedimentology) is acquired, interchanged (e.g., on the Web), stored (e.g., in a database), applied and updated.

i) One goal of knowledge representation and management in geology is to make the explicit and implicit geological knowledge accessible to humans by developing knowledge based and object oriented computer applications, through high-level languages (e.g., XML) that are close to human languages.

j) A conceptual model represents a modeller's perception of the field geology. When designed with Unified Modelling Language (UML), the conceptual model becomes a starting point from which other implementations may be derived.

k) The first step is to define the vocabulary for the domain concepts. These concepts (e.g. fault, earthquake) will be represented by 'classes' in object-oriented languages such as UML.

l) In order to comprehend and handle all aspects of this subset of the system, the system is decomposed into several subsystems or packages, a task which is best done with UML.

m) UML class diagrams define the structure of geological concepts. UML is made of three kinds of building blocks: things, relationships and diagrams.

n) The structural things, represented on the UML diagram with classes, are descriptions of a set of objects (e.g. bedding, unconformity) that share the same attributes, operations, relationship (e.g. composition, aggregation), and semantics.

o) Classes have been shown with a rectangle with three compartments. The top compartment takes the name of the class and may have other ornaments on the UML class diagram, such as stereotype and package identification. The second compartment is for attributes representing the characteristics of the objects, which are shown with the first character in lowercase (e.g. strike, thickness, age). The third compartment shows the list of the operations, representing the methods in the object-oriented programming languages.

p) Many kinds of relationships between classes in a UML model - association, generalization, aggregation and composition has been used in the conceptual data model.

q) Dependency represents a semantic relationship between two things in which a change in one thing affects the semantics of the dependent thing. This relationship is visually rendered as a dashed line, and may be directed from the dependent thing to the independent thing e.g. the Deformation and Fault Rock packages both may depend on the Rock Structure package.

r) An association is a structural relationship that describes a set of links between objects (classes). Association has been shown with a solid line, uni- or bi-directional, with or without label, commonly showing cardinalities and role names. Cardinalities indicate the number of objects that participate in the relationship (0...1 means zero to one object are related). A special kind of association, called aggregation and strong aggregation (composition) has been used to represent a relationship between a whole and its parts.

s) UML can readily be mapped into relational database schema, allowing a one-to-one correspondence between the data storage and the markup language.

6. CONCEPTUAL GEOLOGICAL DATA MODEL

The design of the data model shall begin with development of a conceptual model that describes earth science at a fundamental level using earth science terms and concepts. The purpose of developing a conceptual model is to provide a consistent framework for developing logical and physical data models embedded in a database system. These guide implementation of the information system in a particular computer environment.

The Conceptual Geological Data Model shall be designed with the aim to make it as a technology-neutral model which may form the basis for a web-based interchange format using evolving information technology (e.g., XML). The intended purpose is to allow the sharing of geologic information independent of logical and physical implementations. It is a model of geosciences concepts and the relationships between them with special emphasis on concepts related to information presented on geologic maps. The document is based on standardization efforts of International Standards Organization. **Fig.11** summarizes the major concepts included as Geologic Representations.

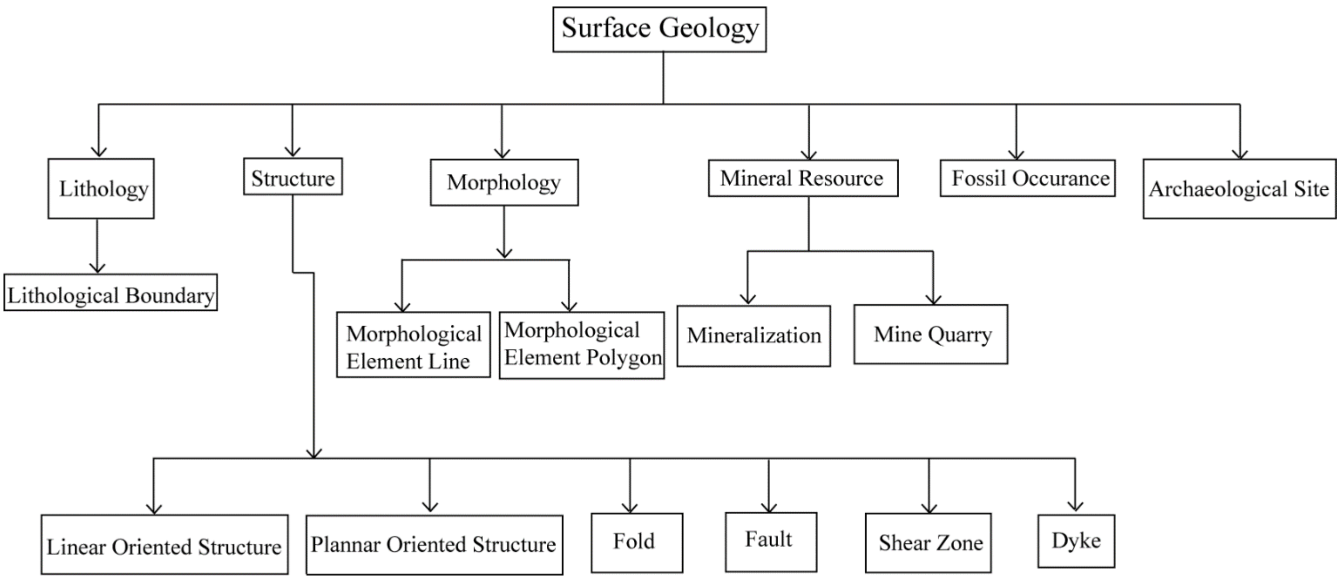


Fig. 11 Conceptual Geological Data Model

6.1 SURFACE GEOLOGY UML MODEL

The properties visible in this model are those which describe the main parts of the Surface Geology data model (in 1:50K Scale).

The Surface Geology Data Model consists of Surface Geological Features as main component to which other components are related. The Surface Geological Features are connected to the below Feature Types:

a) **Lithological Features** give description of different characteristics of lithological unit along with Geological Age, Member, Formation, Subgroup, Group, Supergroup, Intrusive Stratigraphy and Lithological Boundary.

b) **Geological Structure** gives description of different characteristics of Linear and Planar Oriented Structures, Fold, Fault, Dyke, Shear Zone.

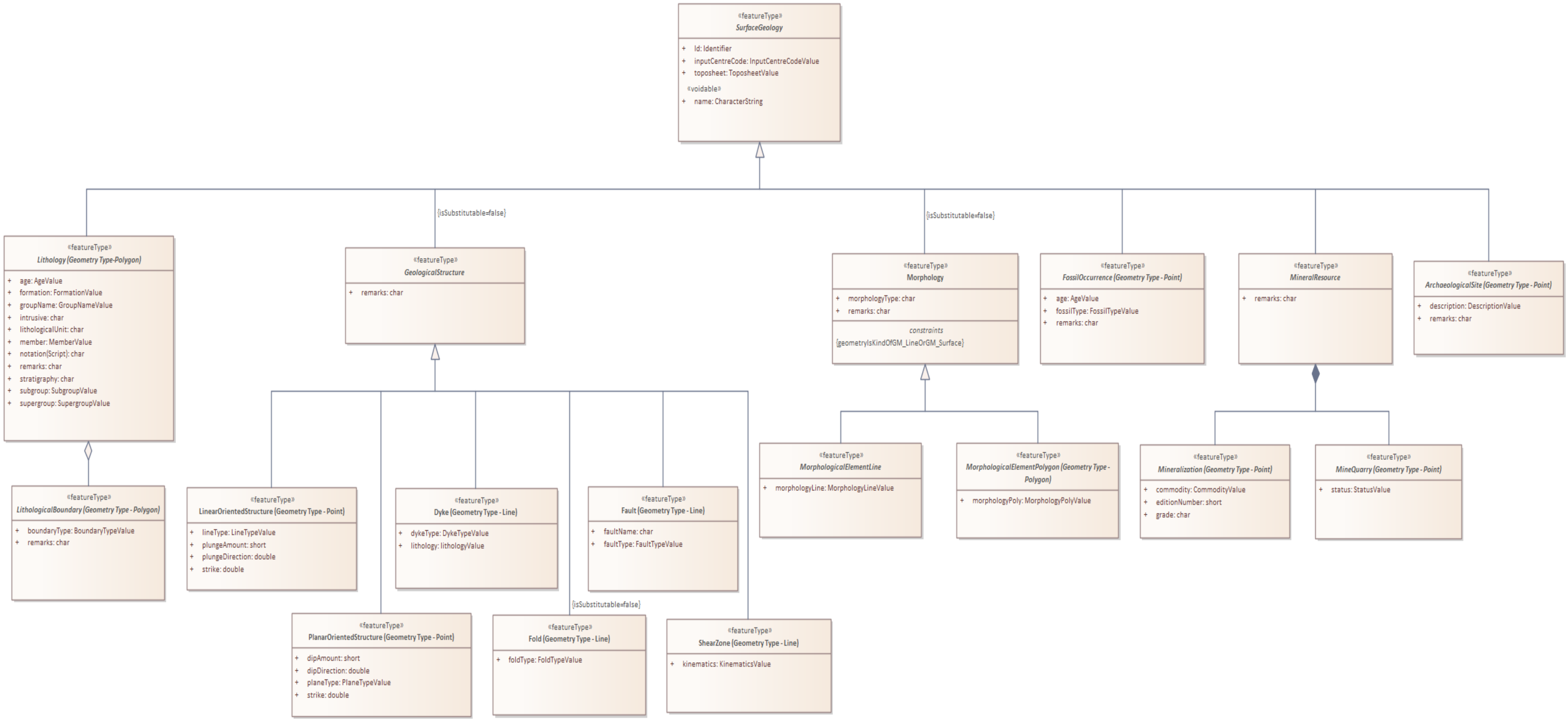
c) **Morphology Features** describe Morphological Type, Linear and Polygonal Morphological Features.

d) **Fossil Occurrence** gives description of Fossil Type and its Geological Age.

e) **Mineral Resource** describes Mineral Commodity, Mineral Grade and Mine Status.

f) **Archaeological Site** gives description of Archaeological Site.

Fig. 12 represents the UML class diagram for the complete 1:50K Surface Geological data


«featureType»
SurfaceGeology
+ Id: Identifier
+ inputCentreCode: InputCentreCodeValue
+ toposheet: ToposheetValue
«voidable»
+ name: CharacterString
{isSubstitutable=false}
{isSubstitutable=false}
«featureType»
Lithology (Geometry Type-Polygon)
+ age: AgeValue
+ formation: FormationValue
+ groupName: GroupNameValue
+ intrusive: char
+ lithologicalUnit: char
+ member: MemberValue
+ notation(Script): char
+ remarks: char
+ stratigraphy: char
+ subgroup: SubgroupValue
+ supergroup: SupergroupValue
«featureType»
GeologicalStructure
+ remarks: char
«featureType»
Morphology
+ morphologyType: char
+ remarks: char
constraints
{geometryIsKindOfGM_LineOrGM_Surface}
«featureType»
FossilOccurrence (Geometry Type - Point)
+ age: AgeValue
+ fossilType: FossilTypeValue
+ remarks: char
«featureType»
MineralResource
+ remarks: char
«featureType»
ArchaeologicalSite (Geometry Type - Point)
+ description: DescriptionValue
+ remarks: char
«featureType»
LithologicalBoundary (Geometry Type - Polygon)
+ boundaryType: BoundaryTypeValue
+ remarks: char
«featureType»
LinearOrientedStructure (Geometry Type - Point)
+ lineType: LineTypeValue
+ plungeAmount: short
+ plungeDirection: double
+ strike: double
«featureType»
Dyke (Geometry Type - Line)
+ dykeType: DykeTypeValue
+ lithology: lithologyValue
«featureType»
Fault (Geometry Type - Line)
+ faultName: char
+ faultType: FaultTypeValue
«featureType»
MorphologicalElementLine
+ morphologyLine: MorphologyLineValue
«featureType»
MorphologicalElementPolygon (Geometry Type - Polygon)
+ morphologyPoly: MorphologyPolyValue
«featureType»
Mineralization (Geometry Type - Point)
+ commodity: CommodityValue
+ editionNumber: short
+ grade: char
«featureType»
MineQuarry (Geometry Type - Point)
+ status: StatusValue
{isSubstitutable=false}
«featureType»
PlanarOrientedStructure (Geometry Type - Point)
+ dipAmount: short
+ dipDirection: double
+ planeType: PlaneTypeValue
+ strike: double
«featureType»
Fold (Geometry Type - Line)
+ foldType: FoldTypeValue
«featureType»
ShearZone (Geometry Type - Line)
+ kinematics: KinematicsValue

6.1.1 *Lithology Model*

The lithology of a rock unit is a description of its physical characteristics visible at outcrop, in hand or core samples, or with low magnification microscopy. Physical characteristics include color, texture, grain size, and composition. Lithology refers to either detailed description of these characteristics, or a summary of the gross physical character of a rock. Lithology is the basis of subdividing rock sequences into individual litho stratigraphic units for the purposes of mapping and correlation between areas. Code lists are modelled as classes in the application schemas. Their values, however, are managed outside of the application schema.

Fig. 13 represents the UML Class diagram: Lithological Unit for 1:50K Map.

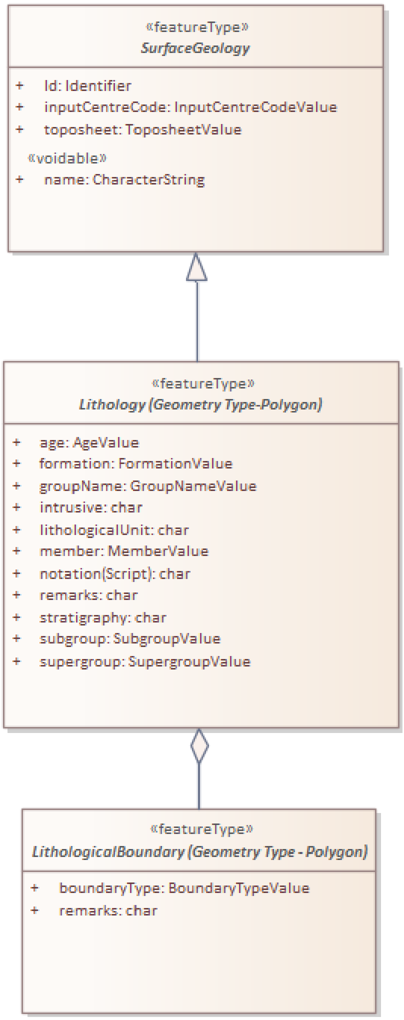


Fig. 13 UML Class diagram: Lithological Unit for 1:50K Map

The logical data model (class diagram) needs to be translated into other forms so that it may be accessible for different purposes. Enterprise Architect provides the facilities to convert the data models into several formats which include Metadata interchange format.

6.1.2 Structure Core Data Model

Geologic Structure is three-dimensional distribution of rock units with respect to their deformational histories on the Earth. The Geologic Structures are independent of the earth material. They are the result of the powerful tectonic forces that occur within the earth giving rise to fold, fractures, faults, joints, mountains building etc.

The scale of geologic structures ranges from microscopic to megascopic. Many of the structural properties concern orientation measurements and specific orientation data types are used for recording these structures.

In the data model Geologic Structure Core there are two types of structures - Primary and Secondary Structure

a) **Primary structures:** those which develop at the time of formation of the rocks. Primary Structures are observed both in igneous and sedimentary rocks. Sedimentary structures are cross bedding, graded bedding and ripple marks. Primary structures in igneous rocks are pillow lava, filled cavities, unconformities etc.

b) **Secondary structures:** are those that develop in rocks after their formation as a result of their subjection to external forces. Secondary structures are of two types - linear and planner.

The attitude of both linear and planar objects has two general components: bearing and inclination. The linear secondary features are fold, fault, trend line, lineation and shear zone represented by the line data. For planar features such as bedding (the boundaries of a bed), fault and foliation, the bearing and inclination become strike and dip, which are represented by the point data on the map. For lineation, we use trend and plunge to represent the bearing and inclination.

The code lists for the geologic structure are primary structure, contact, fold, and fault, shear zone, lineation and fractures whose values are managed from outside application schema.

Fig. 14 represents the UML class diagram for the Geologic Structure Core model**.**

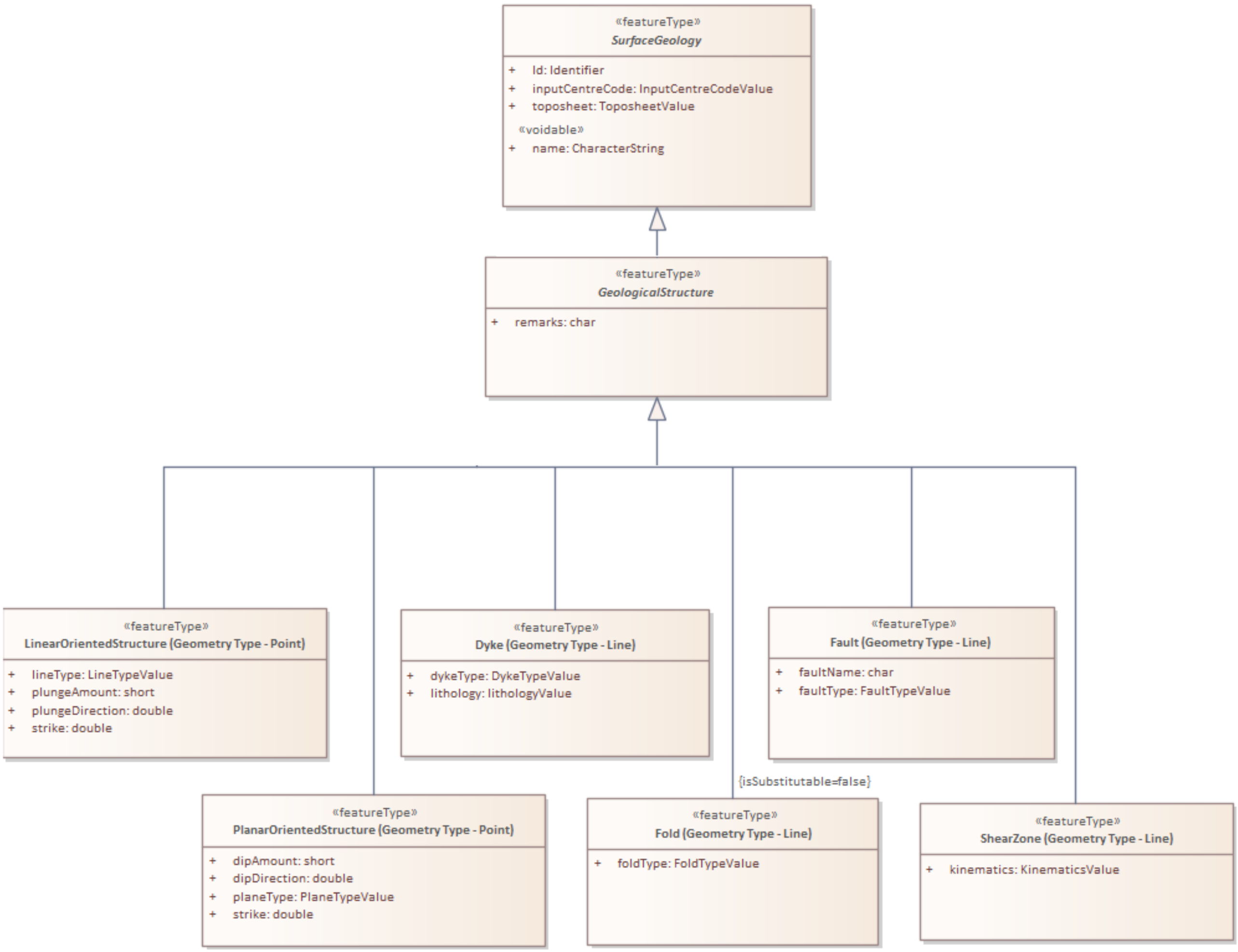


Fig. 14 UML class diagram: Geologic Structure Core model

6.1.3 *Geomorphologic Data Model*

Geomorphology is the study of landforms, with an emphasis on their origin, evolution, form, and distribution across the physical landscapes which are created by physical, chemical or biological processes operating at or near the Earth's surface. Geomorphic feature describes the shape and nature of the Earth's land surface (i.e., a landform). The landforms may be created by natural Earth processes (e.g., river channel, beach, moraine, mountain etc.) or through human (anthropogenic) activity (e.g., dredged channel, reclaimed land, mine waste dumps).

The abstract Geomorphologic Feature class is a linear and polygonal landform. It is a natural or an anthropogenic surface feature and may be erosional, depositional or both.

Fig. 15 represents the UML Class diagram for Geomorphologic Feature.

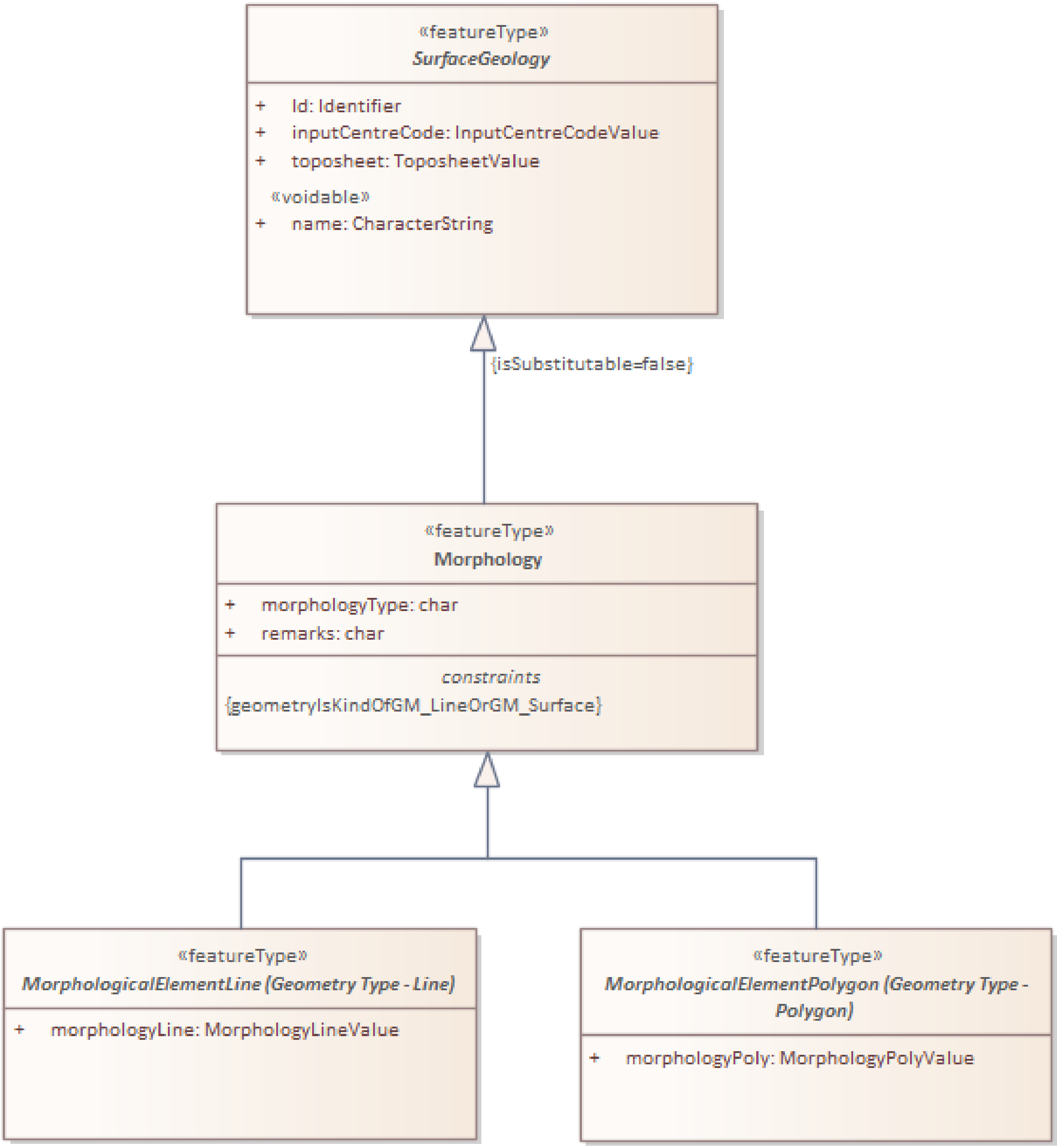


Fig. 15 UML Class diagram: Geomorphologic Feature

6.1.4 *Fossil occurrence data model*

Fossil occurrence pertains to the study of the preservation of fossils and the factors influencing their distribution. Fossils predominantly occur in sedimentary rocks and are frequently located in river valleys, cliffs, hillsides, quarries, and road cuttings. Optimal fossil discovery sites are those where sedimentary rocks are of the appropriate age for the desired fossils.

Fig. 16 represents the UML Class diagram for Fossil occurrence.

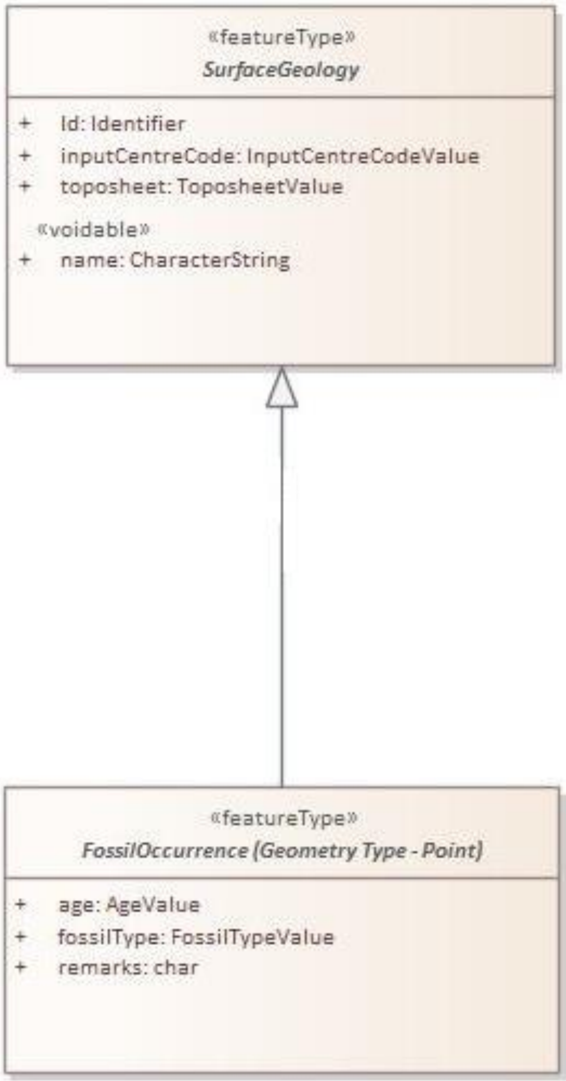


Fig. 16 UML Class diagram: Fossil occurrence

6.1.5 *Mineral resource data model*

A mineral resource is a naturally occurring concentration of minerals in the Earth's crust that may be economically feasible to extract.

Mineralization" refers to the process of economically valuable minerals being deposited in the Earth's crust, often forming concentrated ore bodies or "lodes" through various geological processes like magmatism, hydrothermal activity, or sedimentation, essentially meaning the occurrence of significant quantities of specific minerals that could be potentially mined for profit.

Fig. 17 represents the UML Class diagram: Mineral Resource.

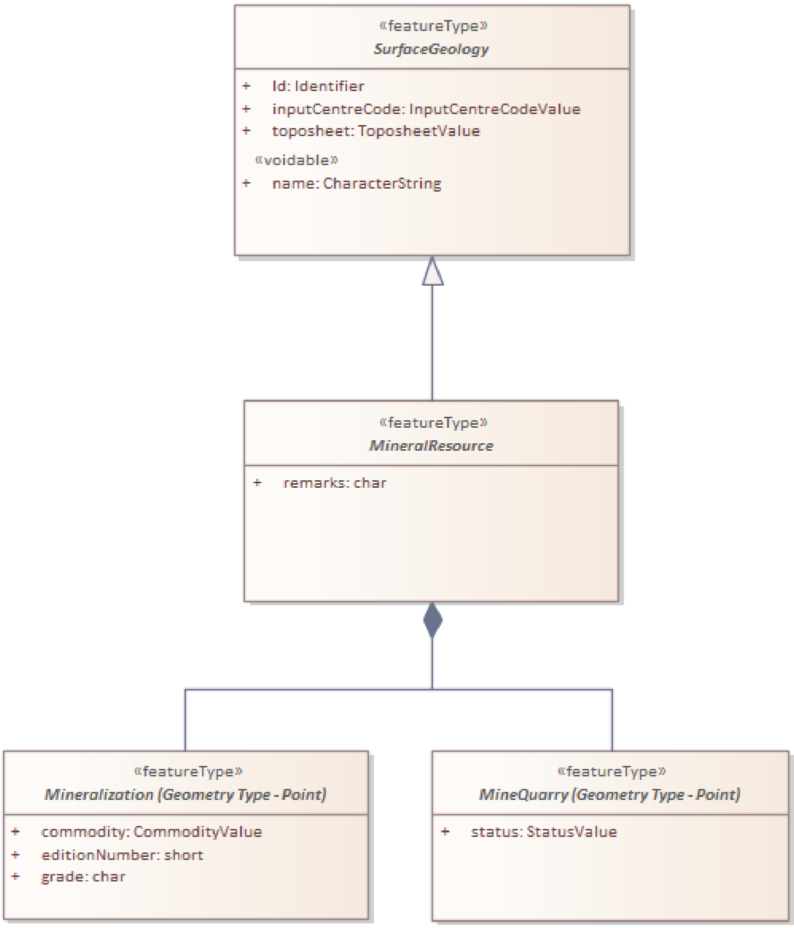


Fig. 17 UML Class diagram: Mineral Resource

6.1.6 *Archaeological site data model*

An archaeological site is a location where physical evidence of past human activity may be found. Fig. 18 represents the UML Class diagram for Archaeological Site.

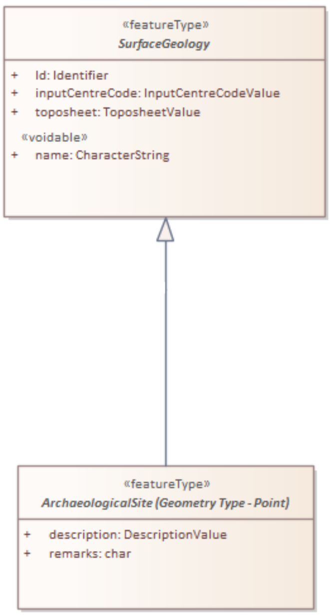


Fig. 18 UML Class diagram: Archaeological Site

ANNEX A

(*Clause 2*)

LIST OF REFFERED INDIAN STANDARDS

Sl. No.	Indian Standards	Title
1	IS 17007	Geographic information - Conceptual Schema Language
2	IS 16626: 2017	Geographical Information – Geography Markup Language (GML)
3	IS 16626 (Part 2): 2018	Geographical Information – Geography Markup Language (GML) - extended schemas and encoding rules

ANNEX B

(*Clause 2*)

LIST OF REFFERED INTERNATIONAL STANDARDS

Sl. No.	International Standards/ Publications.	Title
1	ISO 19107	Geographic information - Spatial Schema
2	ISO 19115-1:2014	Geographic Information-Metadata-Part 1: Fundamentals
3	ISO 19115-2:2019	Geographic information-Metadata-Part 2: Extensions for acquisition and processing
4	ISO 19115-3:2023	Geographic information-Metadata-Part 3: XML schema implementation for fundamental concepts
5	ISO 19144-1: 01	Geographic information – Classification Systems Part 1 – Classification Systems Structure