

Geological and geotechnical modelling of Central Tokyo using proposed IFC4.4 specification extensions

Kazunori Takahashi, Syoichi Nishiyama, Rie Kudo-Wada
OYO Corporation

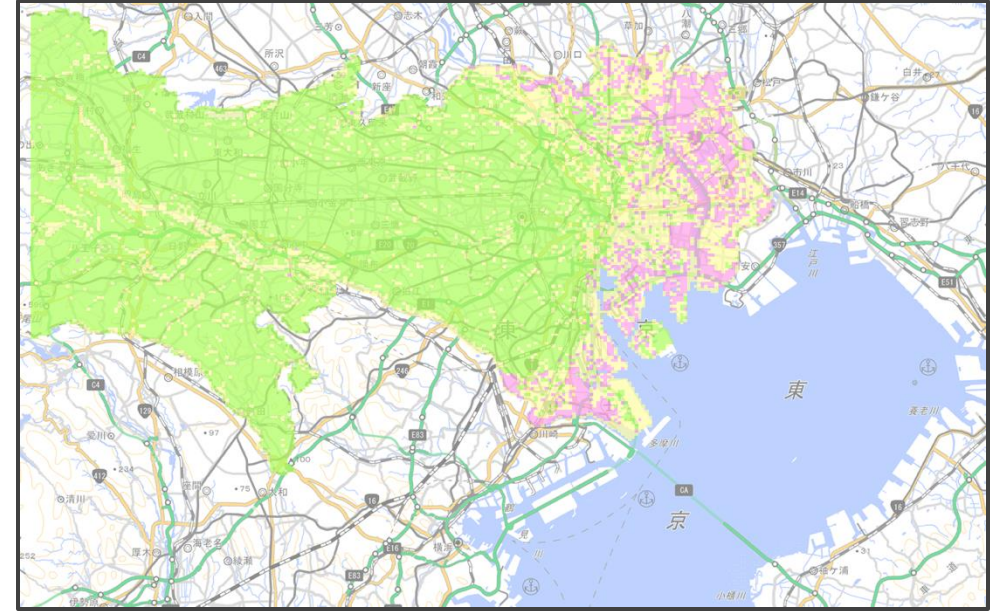
Sergej Muhič
The Hard Code



Introduction

- Tokyo could have serious damage from earthquakes because of:
 - Concentrated urban functions
 - Extremely densely populated
 - Complex geology
 - Coastal area, low elevation
- Creation of hazard maps for the Central Tokyo area
 - Compilation of information on the subsurface
 - 3D subsurface BIM
 - Assessment of geotechnical risks, seismic simulations using voxel models
 - Creation of hazard maps, e.g. shakability map

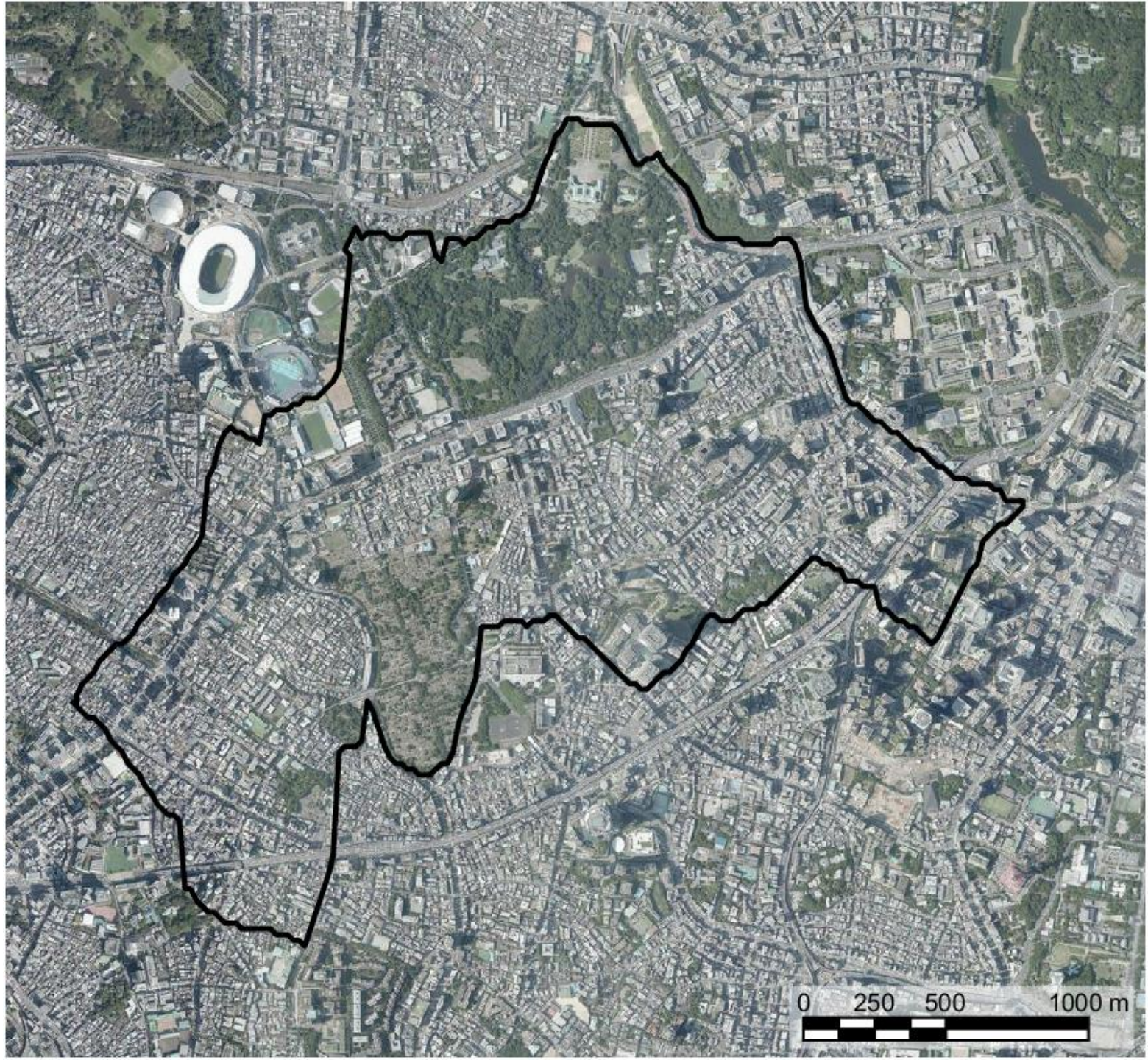
⇒ A good test case of information exchange using IFC



Prediction of liquefaction in Tokyo
Tokyo Metropolitan Government

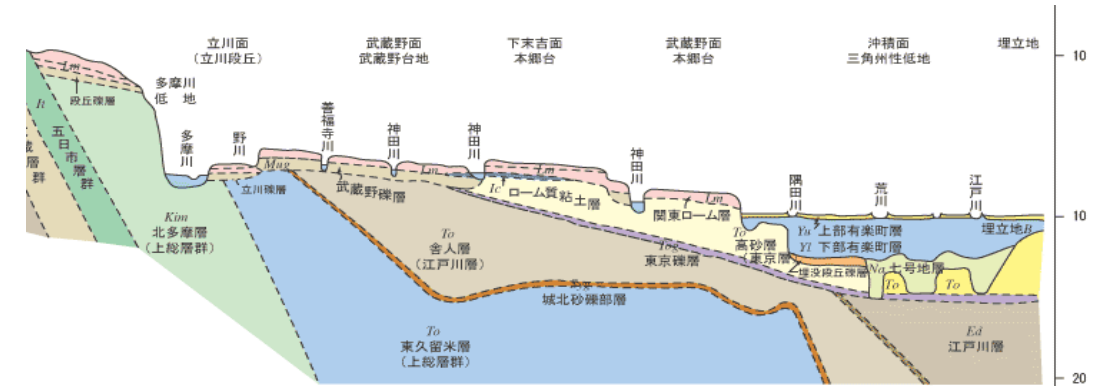
Area of interest

- Dense structures
 - High-rise office buildings
 - Government buildings
 - Luxury apartments
 - Embassies
- Infrastructures
 - Major roads
 - Underground railways



Geological/geotechnical modelling

- Input source data into modelling software
 - Publicly available Maps/DEMs
 - Borehole logs
 - Geological maps/sections by ministries
 - Geological sections by underground railway operators
 - Geological maps/sections in publications
- Identifying layer boundaries
- Adjusting boundaries by comparing with sections
- Generate layer boundaries as surface objects
- Generate solid layers/voxels based on boundary surfaces



Borehole log in soil(for standard penetration test)

Investigation title ○○地区道路地質調査業務

Title of project or construction

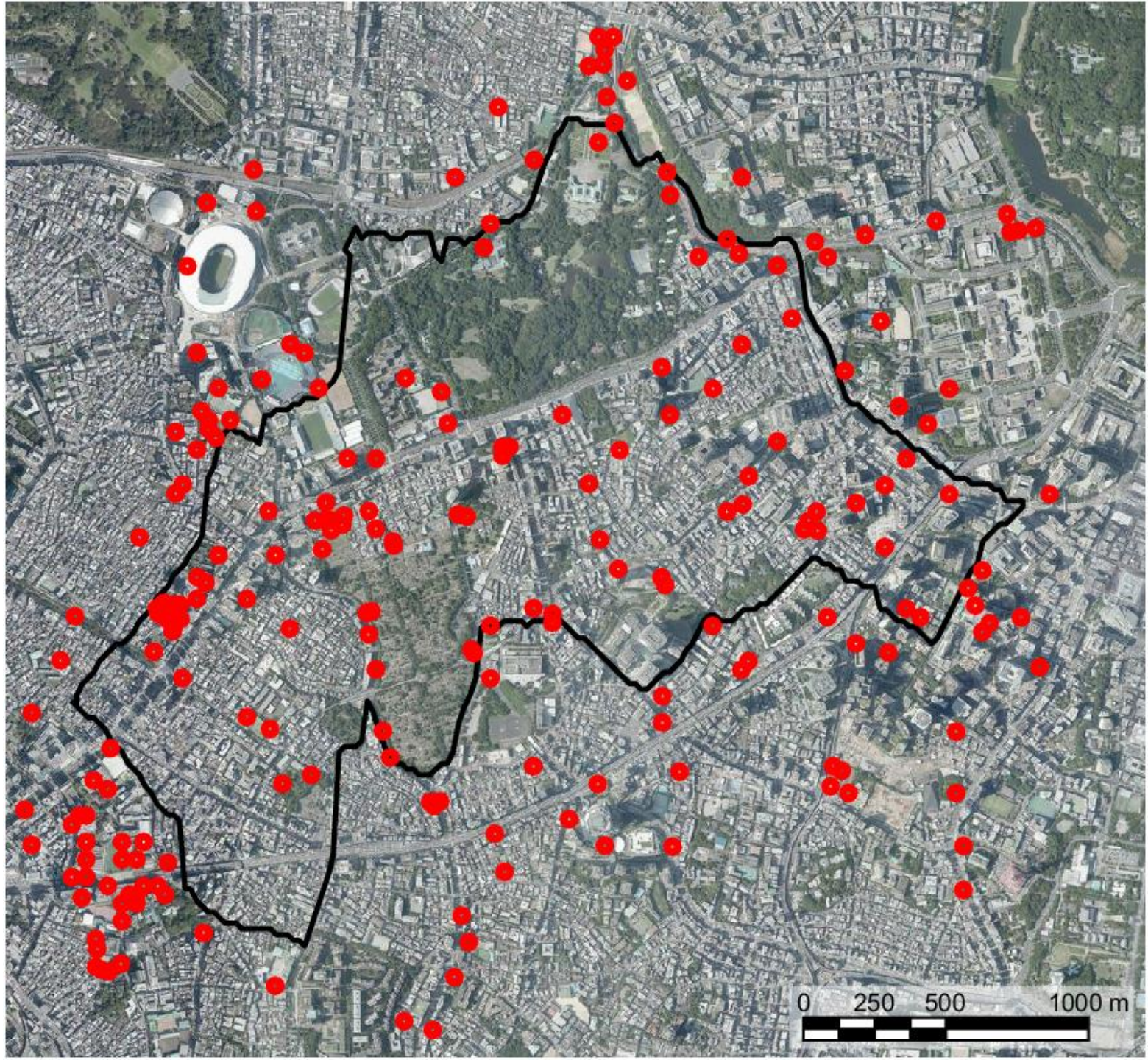
Purpose and object of investigation 道路 トンネル・地下空洞

Borehole No.	X-2	Borehole location	埼玉県さいたま市北区宮原町1-66-2	Latitude	35° 56' 1.5000"
Client				Drilling period	令和06年01月01日～令和06年01月31日
Contractor	応用地質株式会社	Project engineer	電話(043-XXX-XXXX)	Site coordinator	Core appraiser
Elevation of borehole top	T.P. 5.23 m	Inclination	180° 270° 90°	Drilling rig	東邦地下工機 D9-DR
Total depth of drilling	41.00 m	Drilling rig	エンジン	ポンプ	ヤンマー B63B

Drilling date	Soil tests	Sampling	Standard penetration test					Ground water level Measurement date	Description	Relative consistency	Color tones	Classification of geomaterials	Site soil name	Site soil name (graphic symbols)	Depth (m)	Elevation (m)	Scale mark (m)
			Method	Sample numbers	Depth (m)	Penetration at 30 (100) mm blow	Penetration at 50 (100) mm blow										

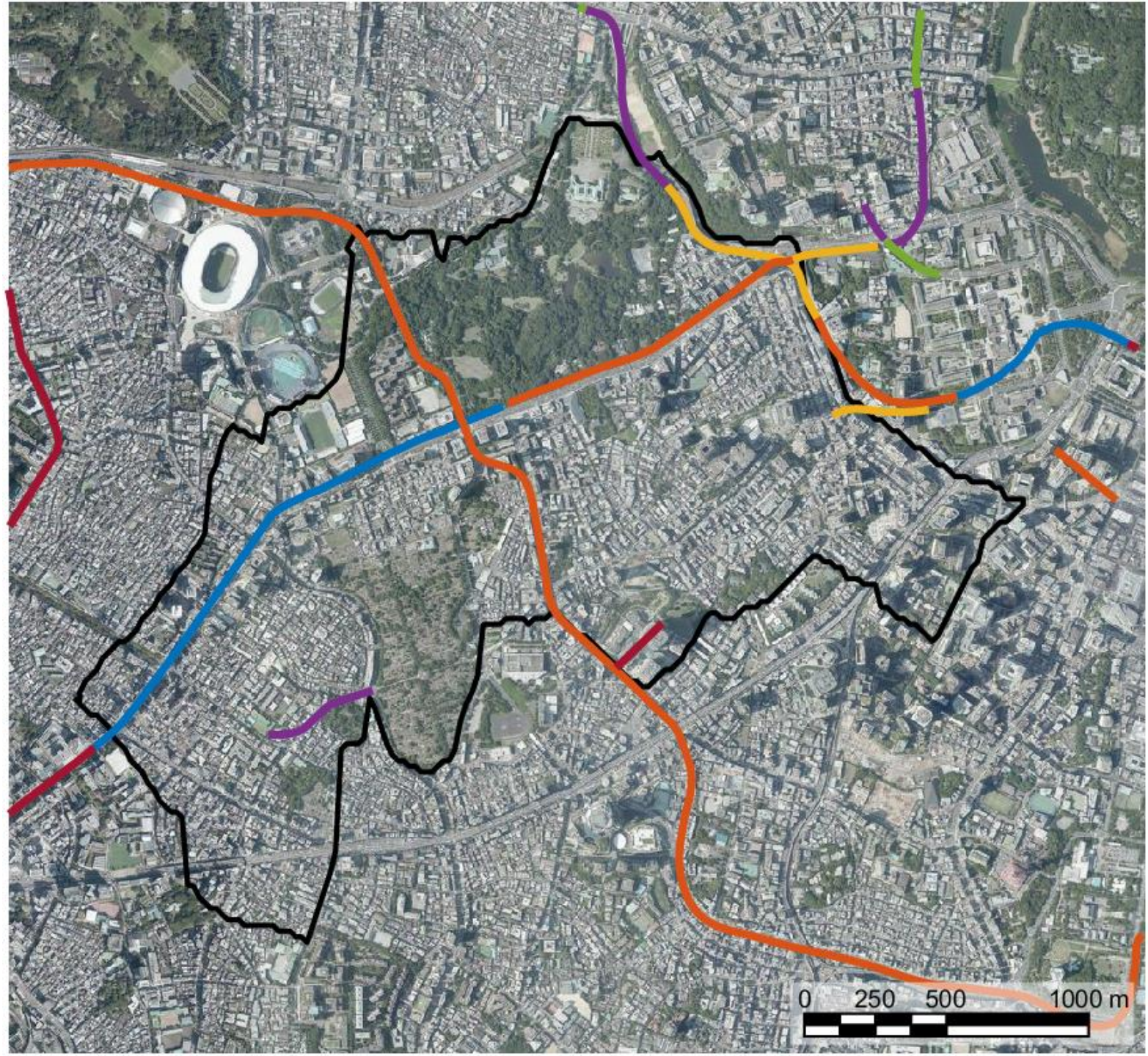
Boreholes

- 235 borehole logs:
 - Tokyo Metropolitan Government
 - Ministry of Land, Infrastructure, Transport, and Tourism
 - Geological Survey of Japan, AIST
 - National Geo-Information Centre

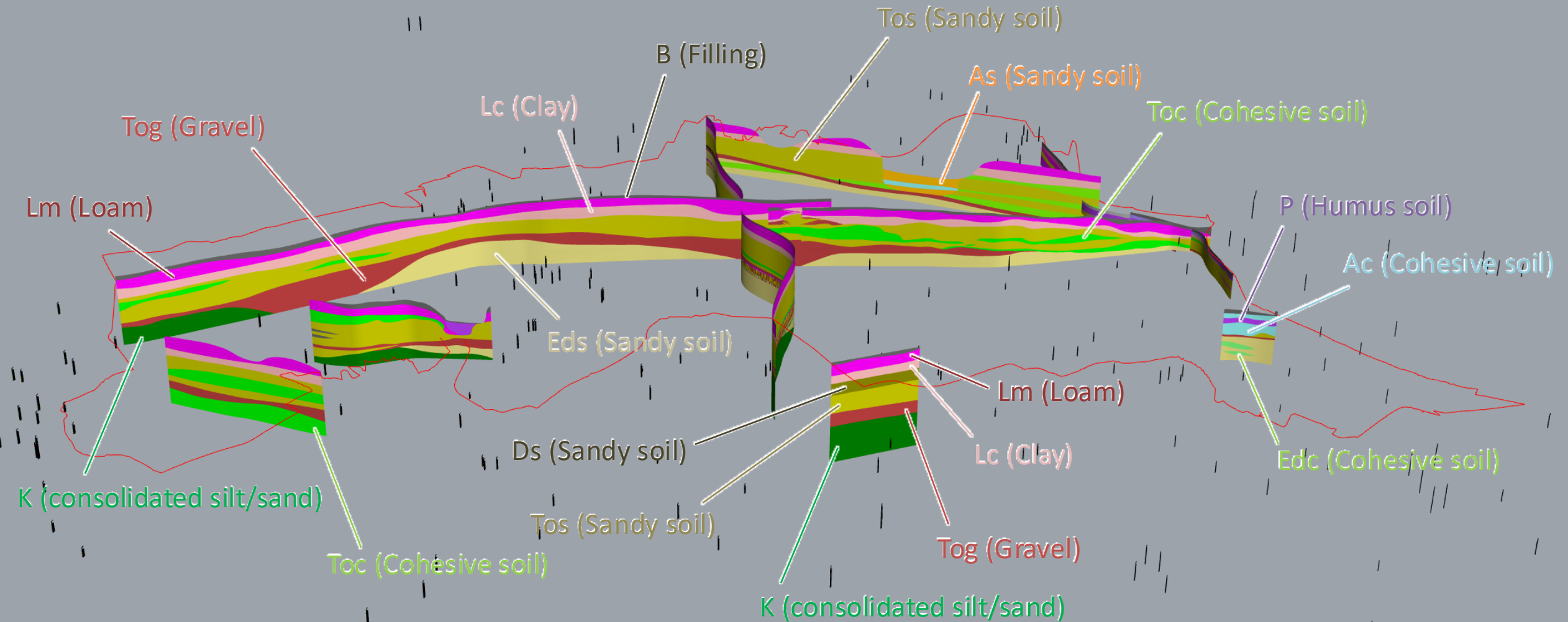


Geological sections

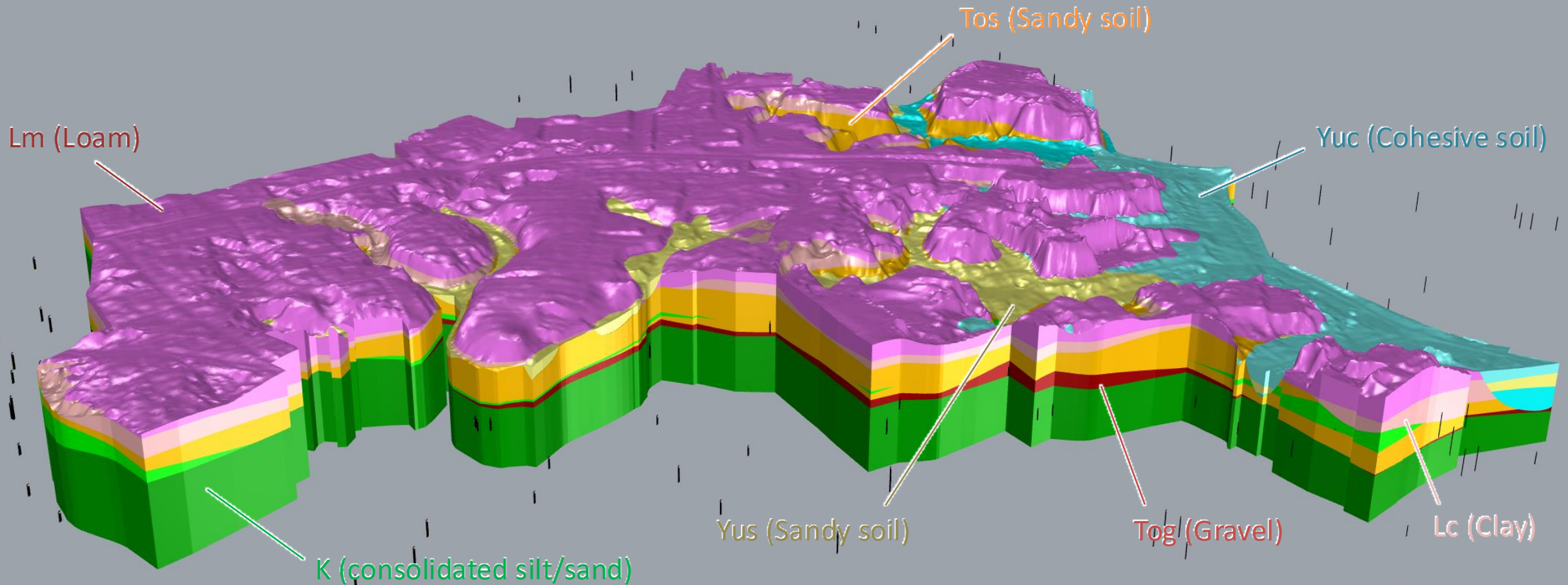
- Ca. 50 geological sections (incl. surrounding area)
 - Tokyo Metropolitan Government
 - Ministry of Land, Infrastructure, Transport and Tourism
 - Underground railway operators



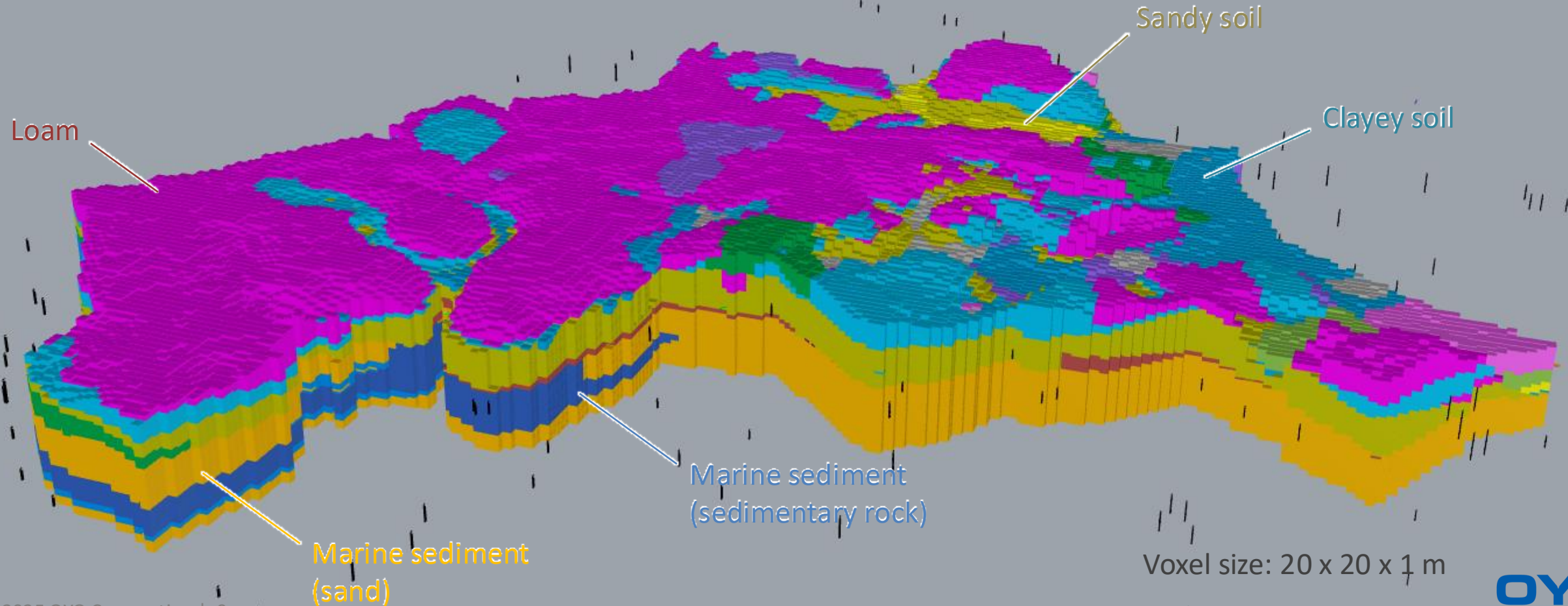
Boreholes/geological sections



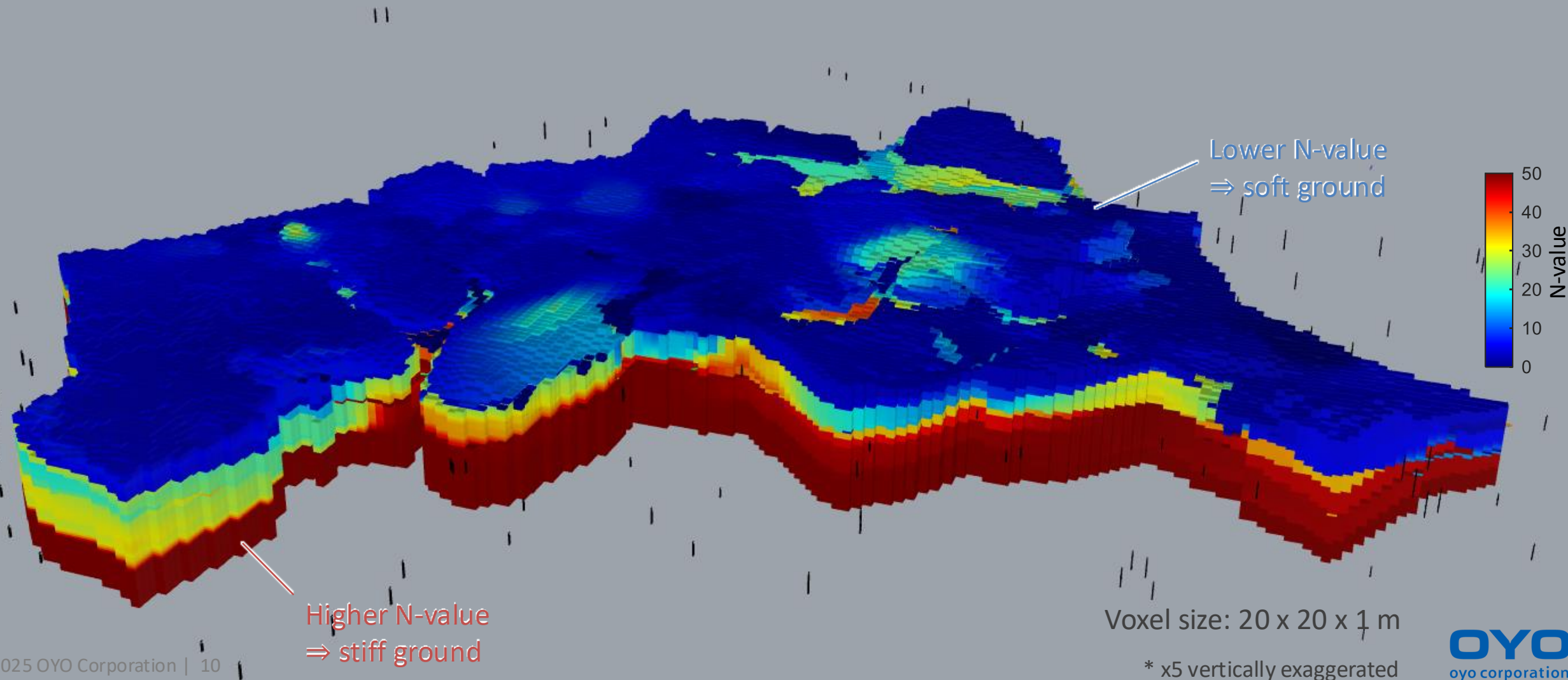
Geological layers



Soil classification (voxel model)



N-value (voxel model)



Modelling using IFC

- Involvement of various parties in the project
Requires information exchanges
⇒ Use of IFC
- IFC4.3 is insufficient to represent geological/geotechnical models
⇒ Need to use generic entities with text description, user-defined property sets
- Tunnel project extensively developed IFC entities/property sets related to geology/geotechnics – IFC4.4
⇒ Use of IFC4.4 as a test case

Tunnel project and IFC4.4

- To develop tunnel-related IFC schema
- 3 scopes:
 - Excavation
 - Systems
 - **Geotechnics**
- Reports and documentation available online



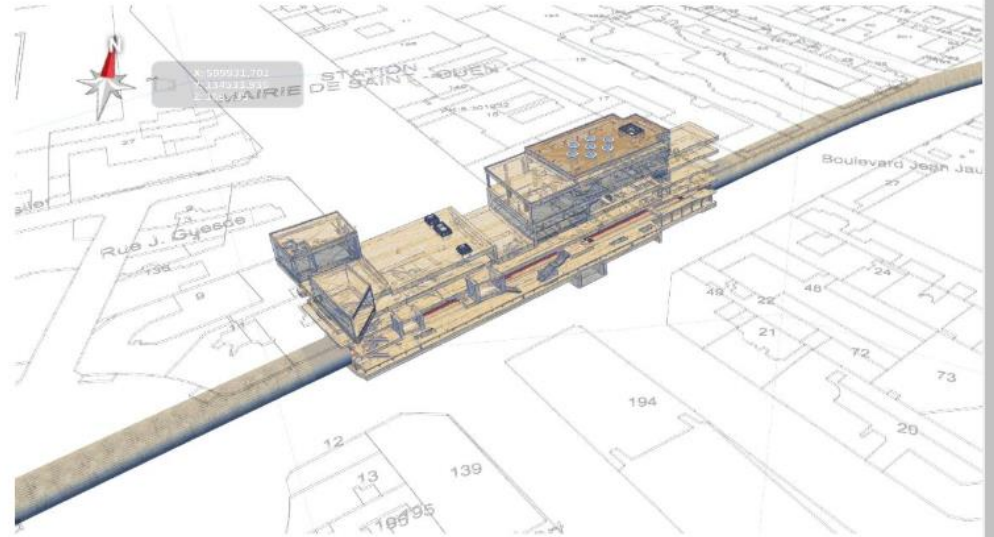
https://bsi-infraroom.github.io/IFC-Documentation-Tunnel/4_4_0_0/general/HTML/

IFC4 Documentation

bsi-infraroom.github.io/IFC-Documentation-Tunnel/4_4_0_0/general/HTML/

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A 3D architectural rendering of a tunnel system. The tunnel is shown as a long, yellowish-brown structure with a cross-section revealing internal components like tracks and ventilation systems. It is overlaid on a detailed city map showing streets, buildings, and a river. A compass rose is visible in the top left corner of the map view.

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WP2 Deliverables Requirements Analysis:

- [Requirement Analysis Report](#)
- [IR-TUN-WP2_Global process map](#)
- [IR-TUN-WP2_Scope proposal](#)

WP3 Deliverables Specification Development - Conceptual Model and guidelines:

- [Conceptual Model Modelling Guidelines](#)
- [Conceptual Model Reading Guide](#)

Tunnel project and IFC4.4

- To develop tunnel-related IFC schema
- 3 scopes:
 - Excavation
 - Systems
 - **Geotechnics**
- Reports and documentation available online



https://bsi-infraroom.github.io/IFC-Documentation-Tunnel/4_4_0_0/general/HTML/

IFC4 Documentation

bsi-infraroom.github.io/IFC-Documentation-Tunnel/4_4_0_0/general/HTML/

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F. Change logs

F.1 IFC2x3 to IFC4 4.0.0.0

F.1.1 Entities

F.1.2 Properties

F.1.3 Quantities

F.1.3 Model Views

F.2 IFC4 Addendum 1 4.0.1.0

F.2.1 Entities

F.2.2 Properties

F.2.3 Quantities

F.2.3 Model Views

F.3 IFC4 Addendum 2 4.0.2.0

F.3.1 Entities

F.3.2 Properties

F.3.3 Quantities

F.3.3 Model Views

F.4 IFC4 Addendum 2 Technical Corrigendum 1 4.0.2.1

F.4.1 Entities

F.4.2 Properties

F.4.3 Quantities

F.4.3 Model Views

F.5 IFC4x1 Final 4.1.0.0

F.5.1 Entities

F.5.2 Properties

F.5.3 Quantities

F.5.3 Model Views

F.6 IFC4x2 Candidate 4.2.0.0

F.6.1 Entities

F.6.2 Properties

F.6.3 Quantities

F.6.3 Model Views

F.13.1 Entities

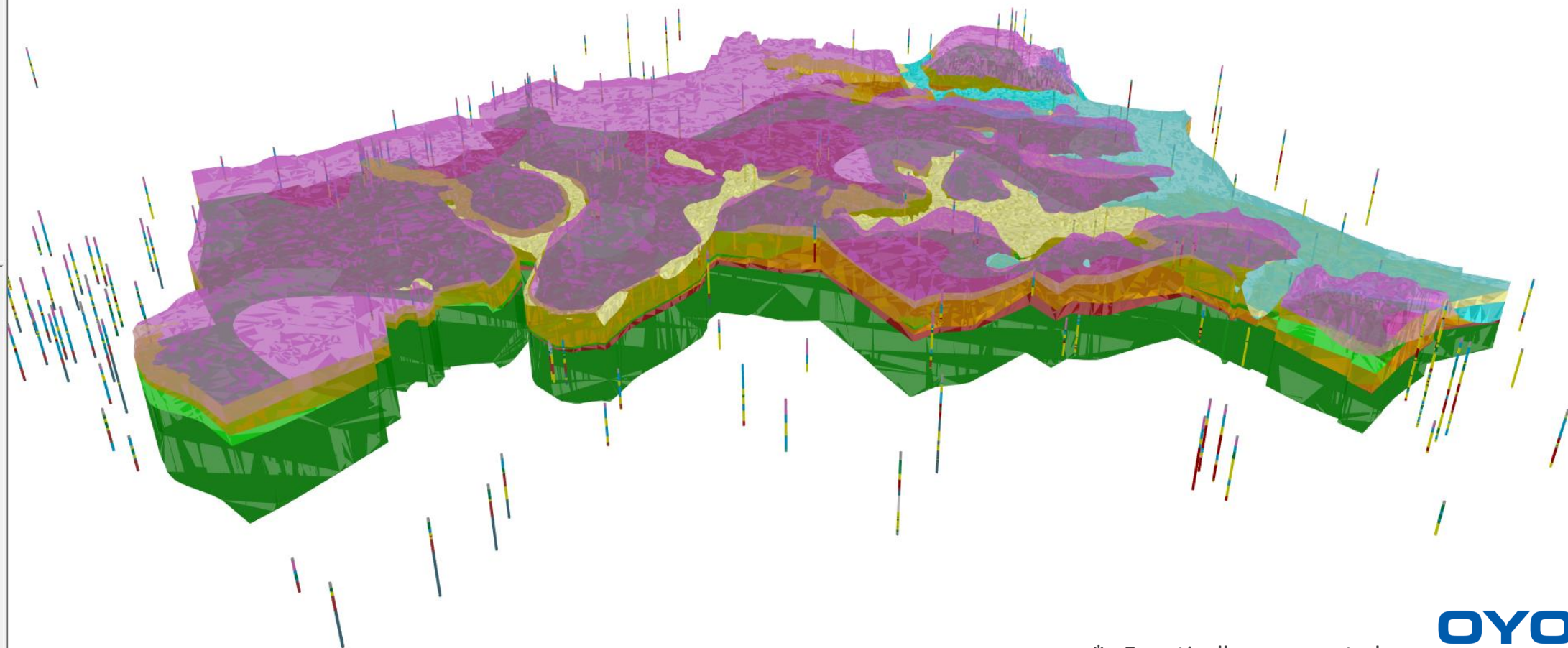
Item	SPF	XML	Change	Description	Bucket
CORE DATA SCHEMAS					
IFCKERNEL					
IfcRelAssociatesDataset			ADDED		C
IFCPRODUCTEXTENSION					
IfcBuiltSystemTypeEnum					
TUNNEL_PRESUPPORT			ADDED		C
TUNNEL_SUPPORT			ADDED		C
TUNNEL_LINING			ADDED		C
WATERPROOFING			ADDED		C
FIREPROTECTION			ADDED		C
IfcElementAssemblyTypeEnum					
DUCTBANK			ADDED		C
PRESUPPORTVAULT			ADDED		C
PRESUPPORTFACE			ADDED		C
RING			ADDED		C
IfcSpatialZoneTypeEnum					
MAPPEDZONE			ADDED		B
TESTEDZONE			ADDED		B
COMPARTMENT			ADDED		C
ANNULARGAP			ADDED		C
CLEARANCE			ADDED		C
INSTALLATION			ADDED		C
INTERIOR			ADDED		C
INVERT			ADDED		C
LINING			ADDED		C
SERVICE			ADDED		C
IfcComplementaryData			ADDED		B
IfcIntegerVoxelData			ADDED		C
IfcLabelVoxelData			ADDED		C
IfcLinearZone			ADDED		B

Header Info
[-] IfcProject 'Akasaka'
[-] geometry
[-] IfcSite
[-] geometry
[+] IfcBorehole 'GS-KO-1_20210127'
[+] IfcBorehole 'GS-MT-1_20210127'
[+] IfcBorehole '代々木公園_20210127'
[+] IfcBorehole '45414'
[+] IfcBorehole '45434'
[+] IfcBorehole '45706'
[+] IfcBorehole '45707'
[+] IfcBorehole '45768'
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[+] IfcBorehole '50045'
[+] IfcBorehole '50046'
[+] IfcBorehole '50057'
[+] IfcBorehole '50062'
[+] IfcBorehole '50064'
[+] IfcBorehole '50065'

Model on RDF IFC Viewer

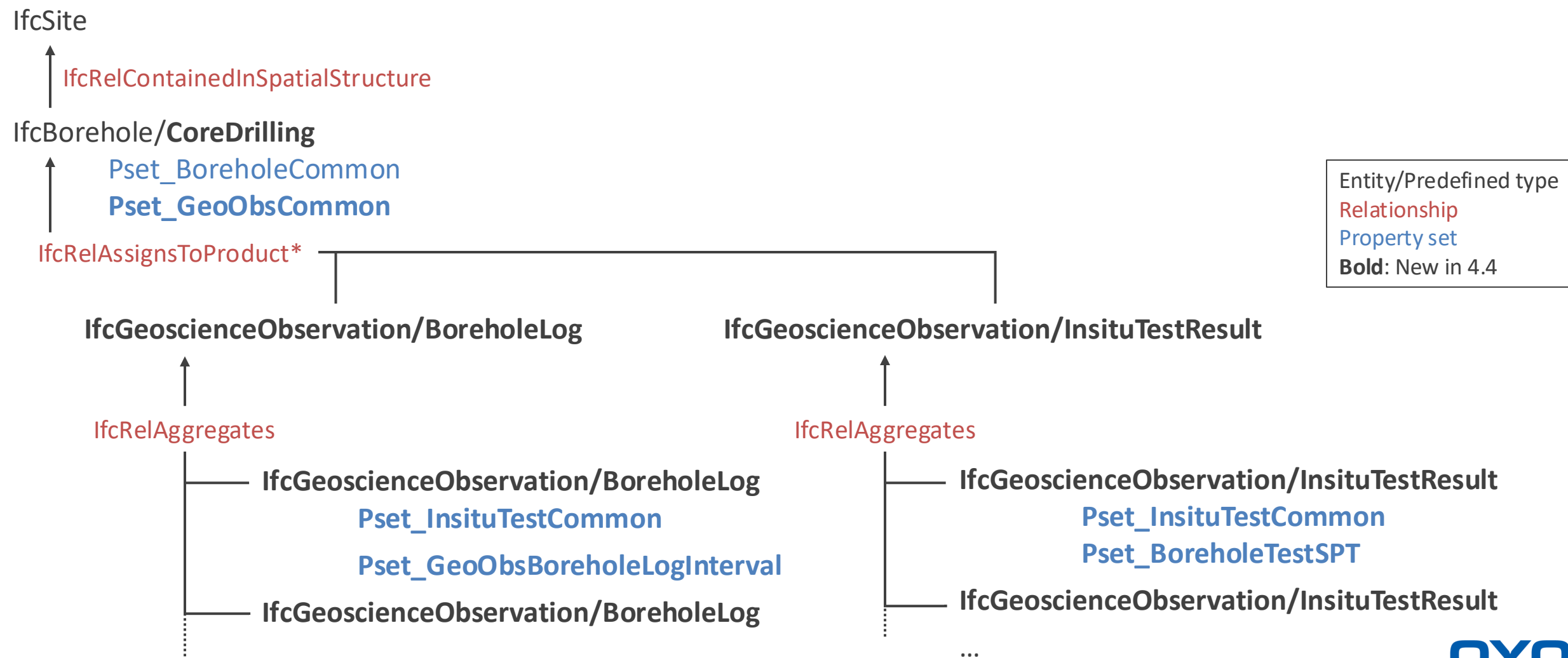
- Boreholes (logs, SPT)
- Geological sections
- Geological layers
- Voxels (soil classification, N-value)

Attribute	Value
#	298858
Entity	IfcSystem
[-] IfcRoot	
1: GlobalId	'4YV54x\$Cv1001FAcmvt...
2: OwnerHistory	#20
3: Name	'Sections'
4: Description	'Group of sections'
[-] IfcObjectDefinition	
INV: HasAssignments	()
INV: Nests	()
INV: IsNestedBy	()
INV: HasContext	()
INV: IsDecomposedBy	()
INV: Decomposes	()
INV: HasAssociations	()
[-] IfcObject	
5: ObjectType	"
INV: IsDeclaredBy	()
INV: Declares	()
INV: IsTypedBy	()
INV: IsDefinedBy	()
[-] IfcGroup	
INV: IsGroupedBy	(#298859)
INV: ReferencedInStr...	()
[-] IfcSystem	
INV: ServicesBuildings	()
INV: ServicesFacilities	()

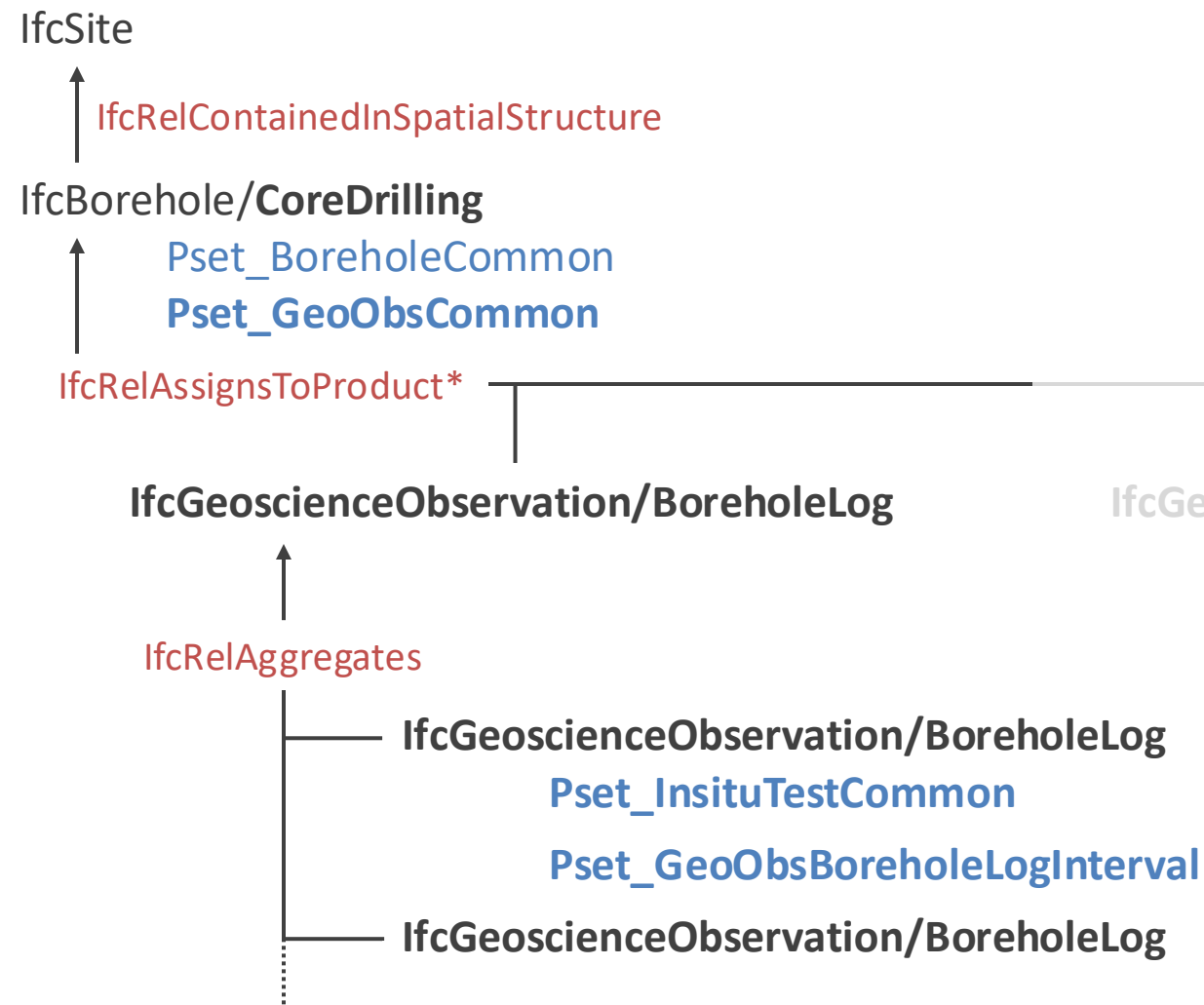


* x5 vertically exaggerated

Data model – Borehole logs



Data model – Borehole logs



IfcGeoScienceObservation

Concept usage

Observation Composition

The [Complementary Data Composition](#) concept template applies to this entity as shown in Table 314.

Decomposes	RelatingObject
	IfcGeoScienceObservation

Table 314 — IfcGeoScienceObservation Complementary Data Composition

An [IfcGeoScienceObservation](#) may decompose another [IfcGeoScienceObservation](#). This may be the case e.g. when several different types of tests have been performed in an [IfcBorehole](#) at different depths and each type of test is decomposed into sub-tests at different depth ranges.

Observation Assignment

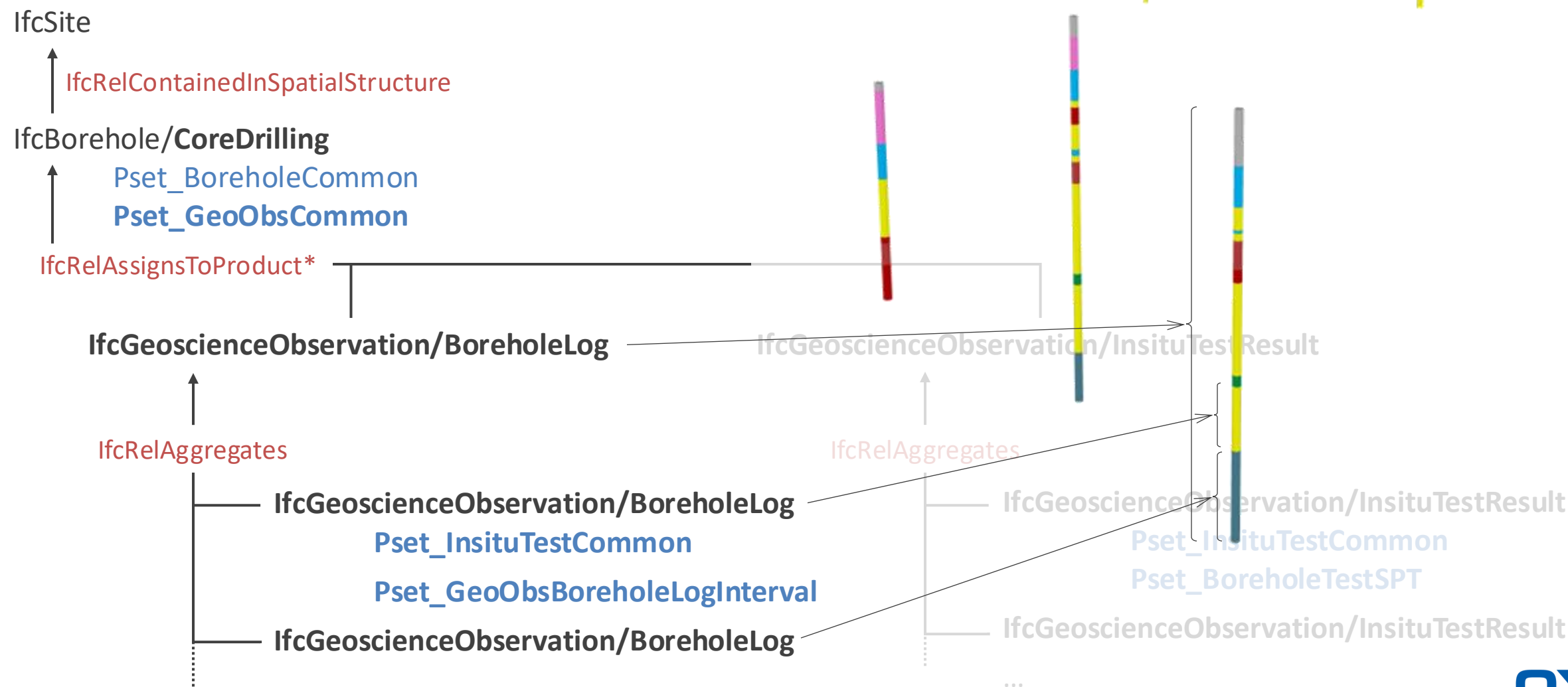
The [Assignment to Product](#) concept template applies to this entity as shown in Table 316.

IsAssigned	RelatingProduct
	IfcBorehole
	IfcSpatialZone
	IfcSensor

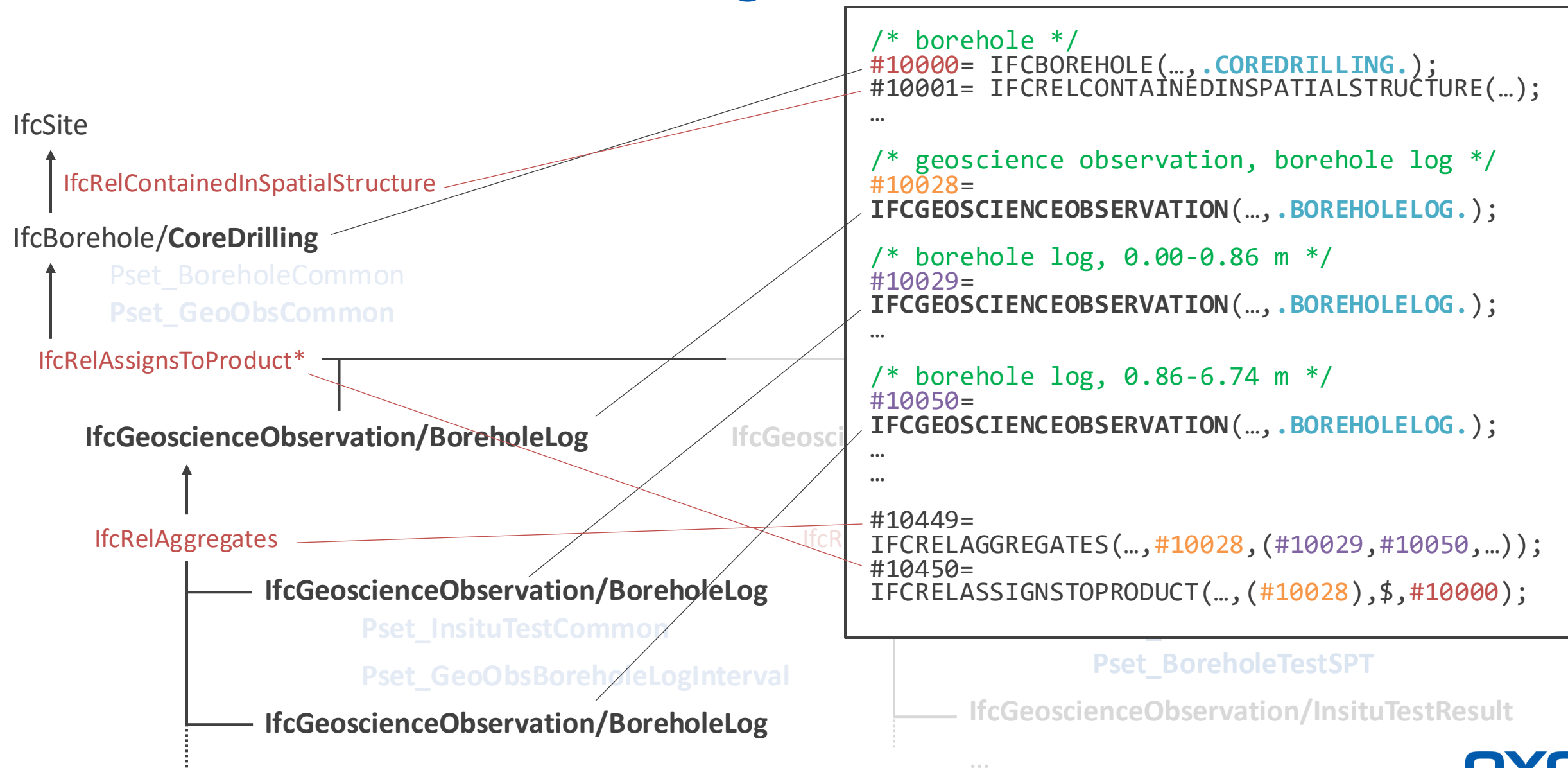
Table 316 — IfcGeoScienceObservation Assignment to Product

An [IfcGeoScienceObservation](#) may be assigned to [IfcBorehole](#), [IfcSpatialZone](#) or [IfcSensor](#).

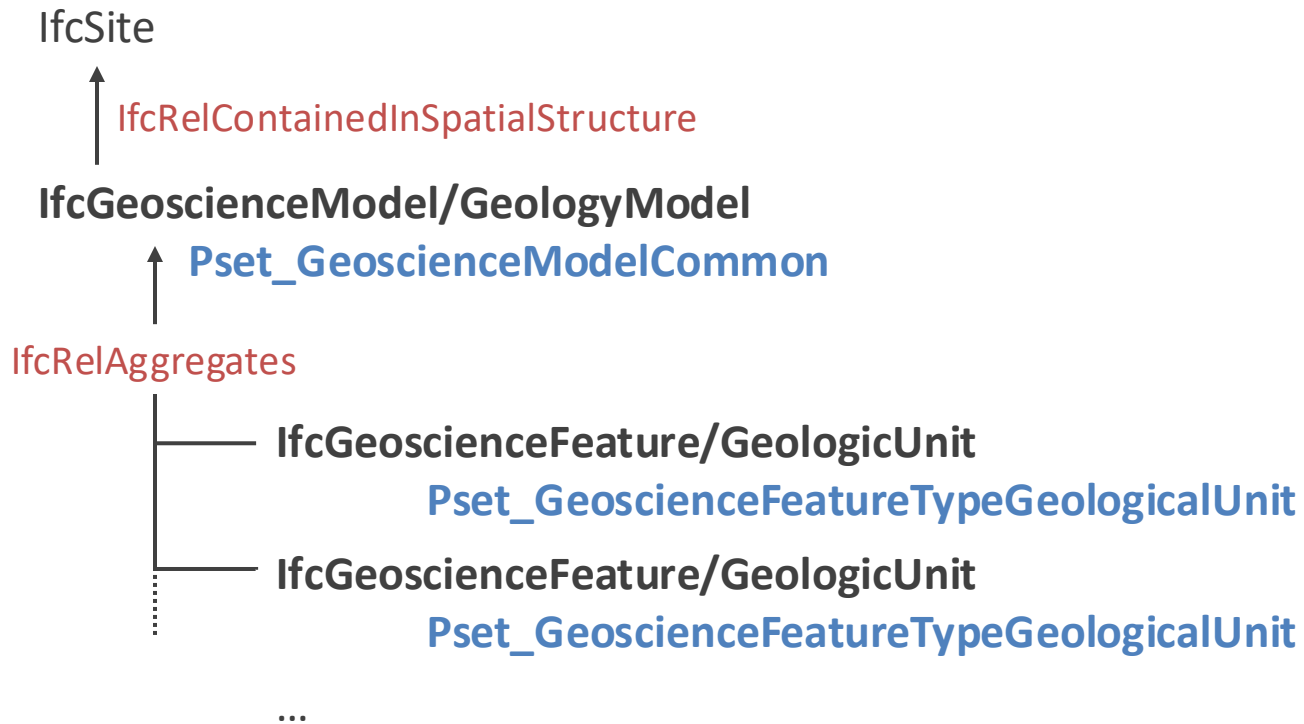
Data model – Borehole logs



Data model – Borehole logs

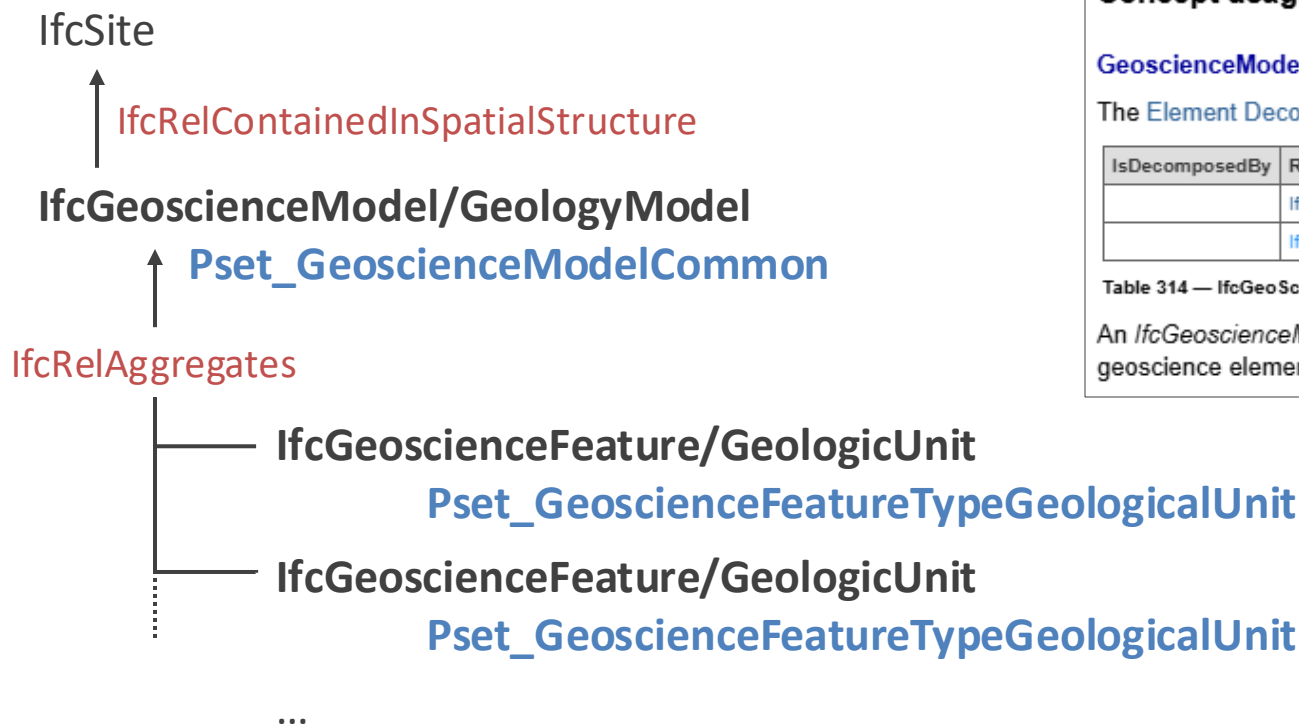


Data model – Geological sections/layers



Entity/Predefined type
Relationship
Property set
Bold: New in 4.4

Data model – Geological sections/layers



IfcGeoscienceModel

Concept usage

GeoscienceModel Decomposition

The [Element Decomposition](#) concept template applies to this entity as shown in Table 314.

IsDecomposedBy	RelatedObjects
	IfcGeoScienceFeature
	IfcGeoScienceModel

Table 314 — IfcGeoScienceModel Element Decomposition

An *IfcGeoscienceModel* may be decomposed into other *IfcGeoscienceModel* geoscience elements or into *IfcGeoscienceFeature* geoscience elements.

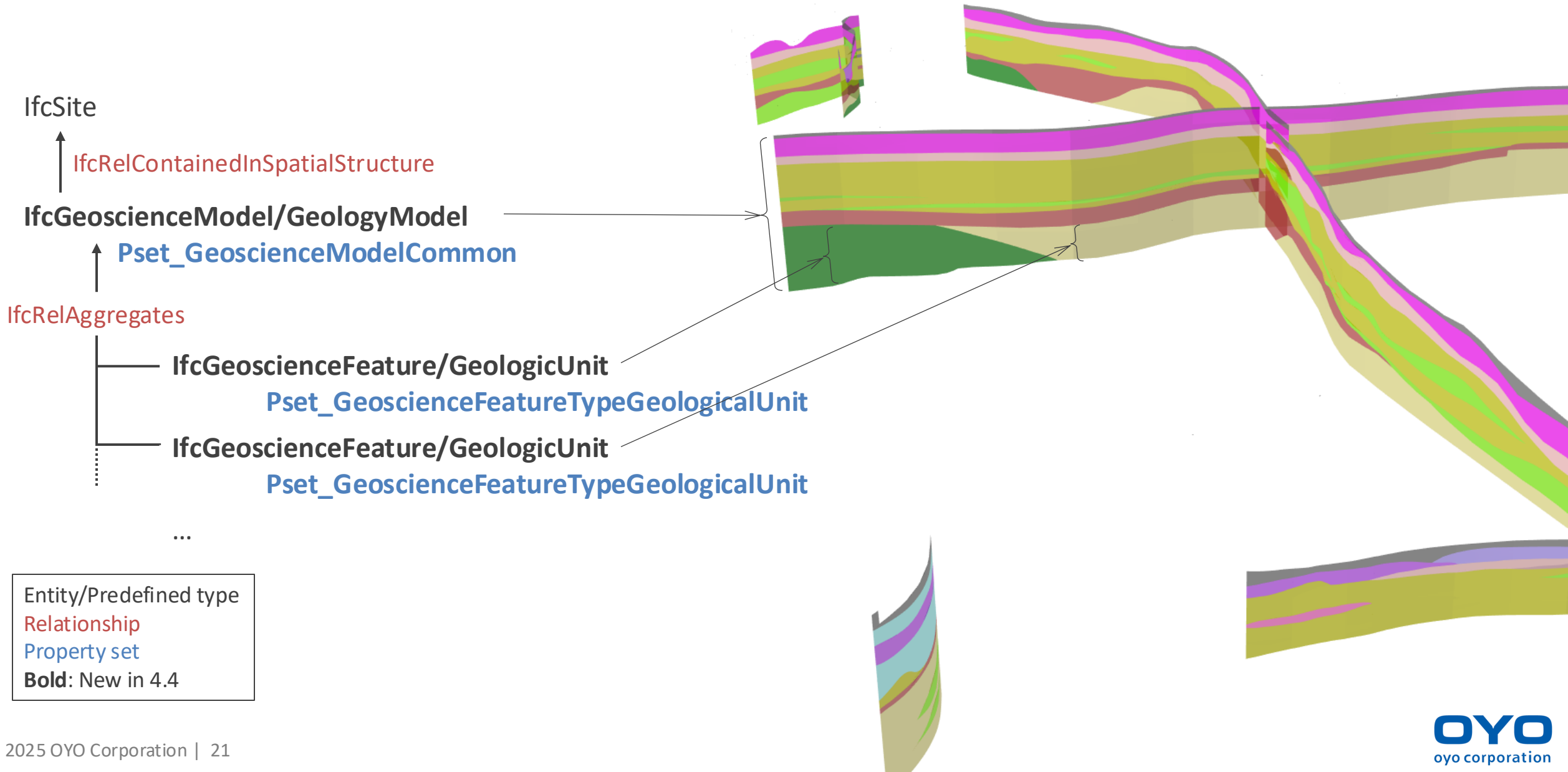
Entity/Predefined type

Relationship

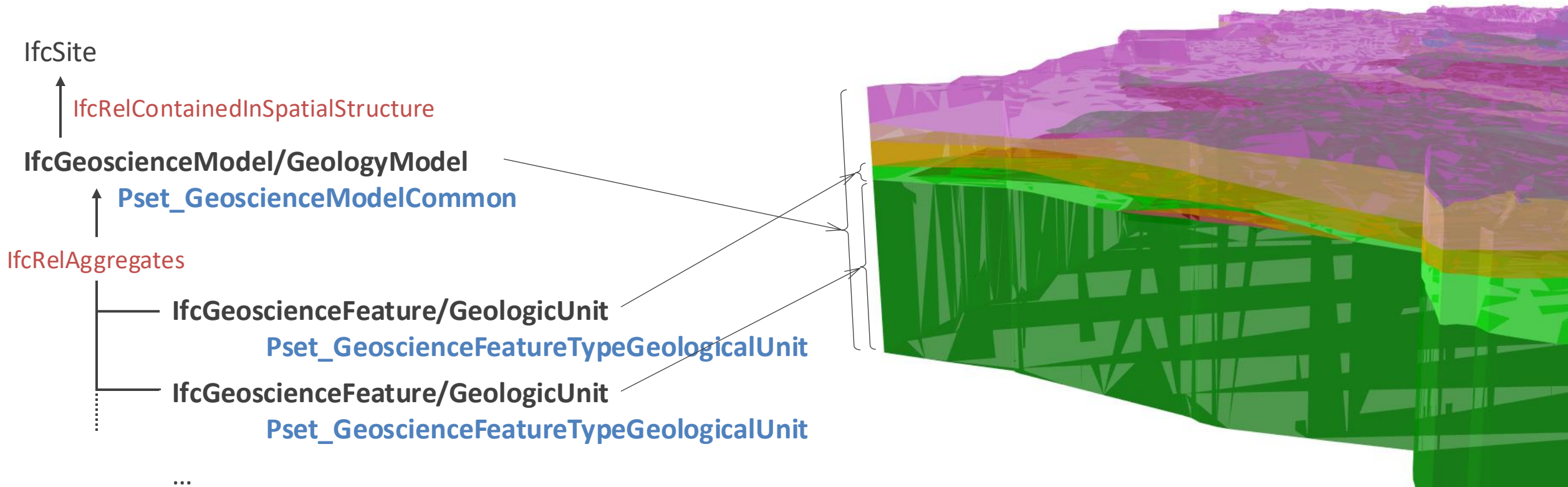
Property set

Bold: New in 4.4

Data model – Geological sections/layers

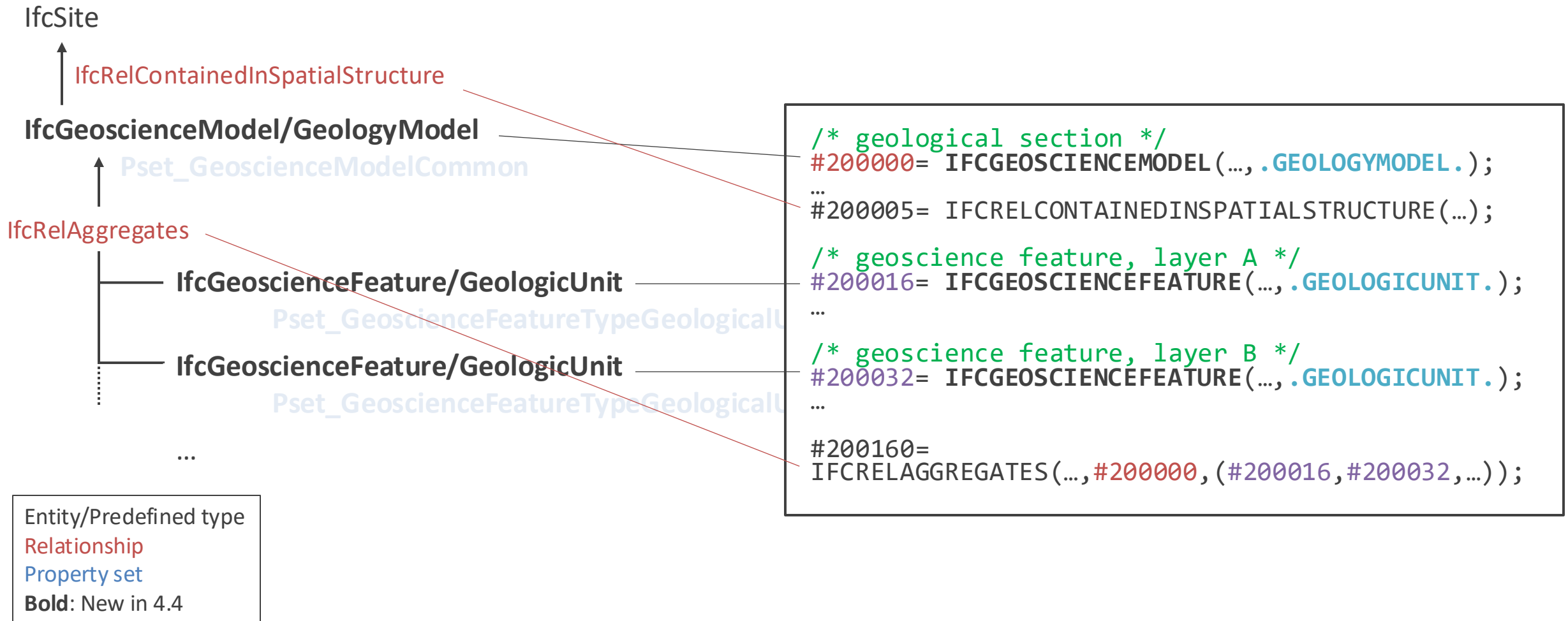


Data model – Geological sections/layers

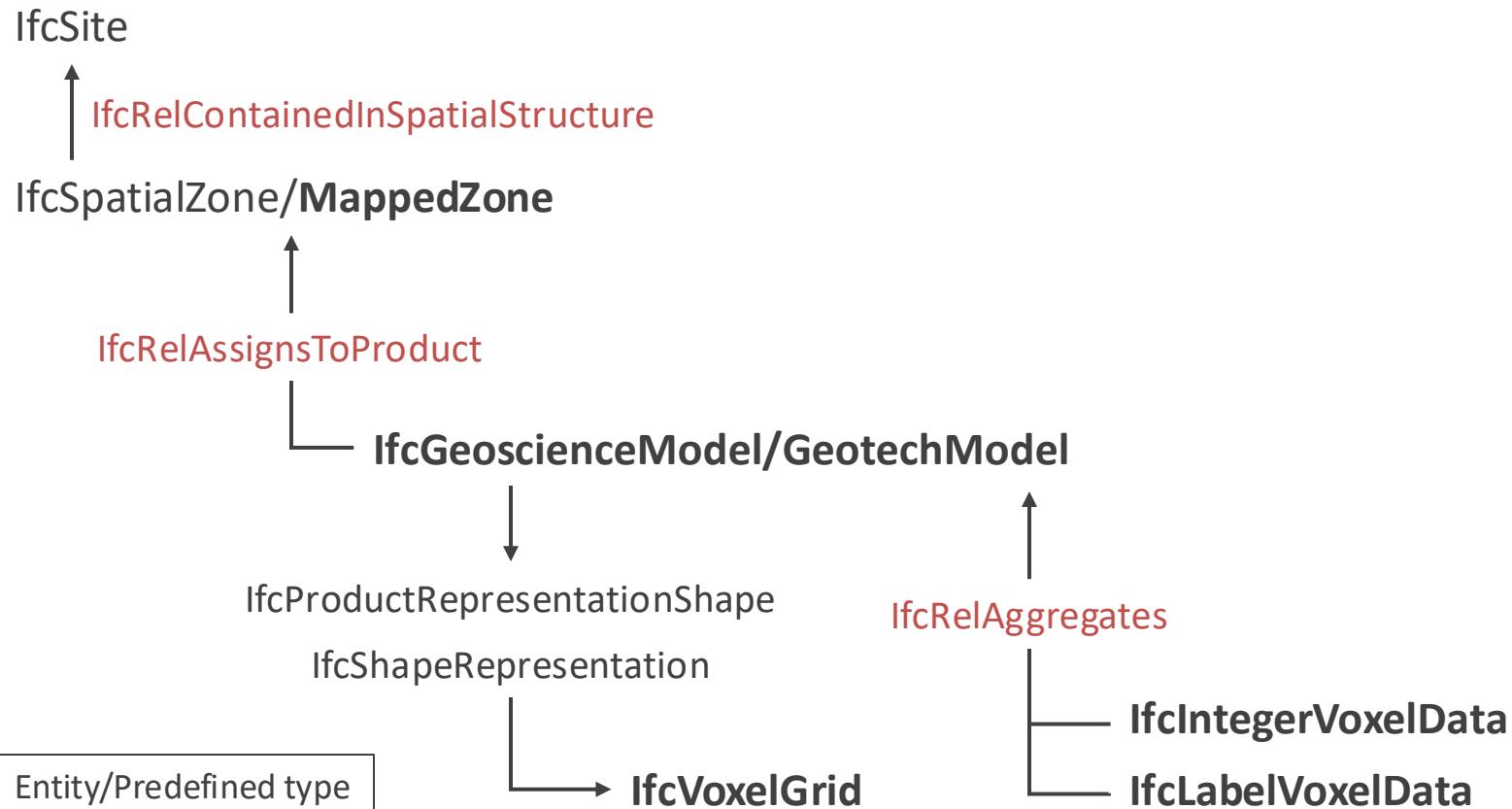


Entity/Predefined type
Relationship
Property set
Bold: New in 4.4

Data model – Geological sections/layers

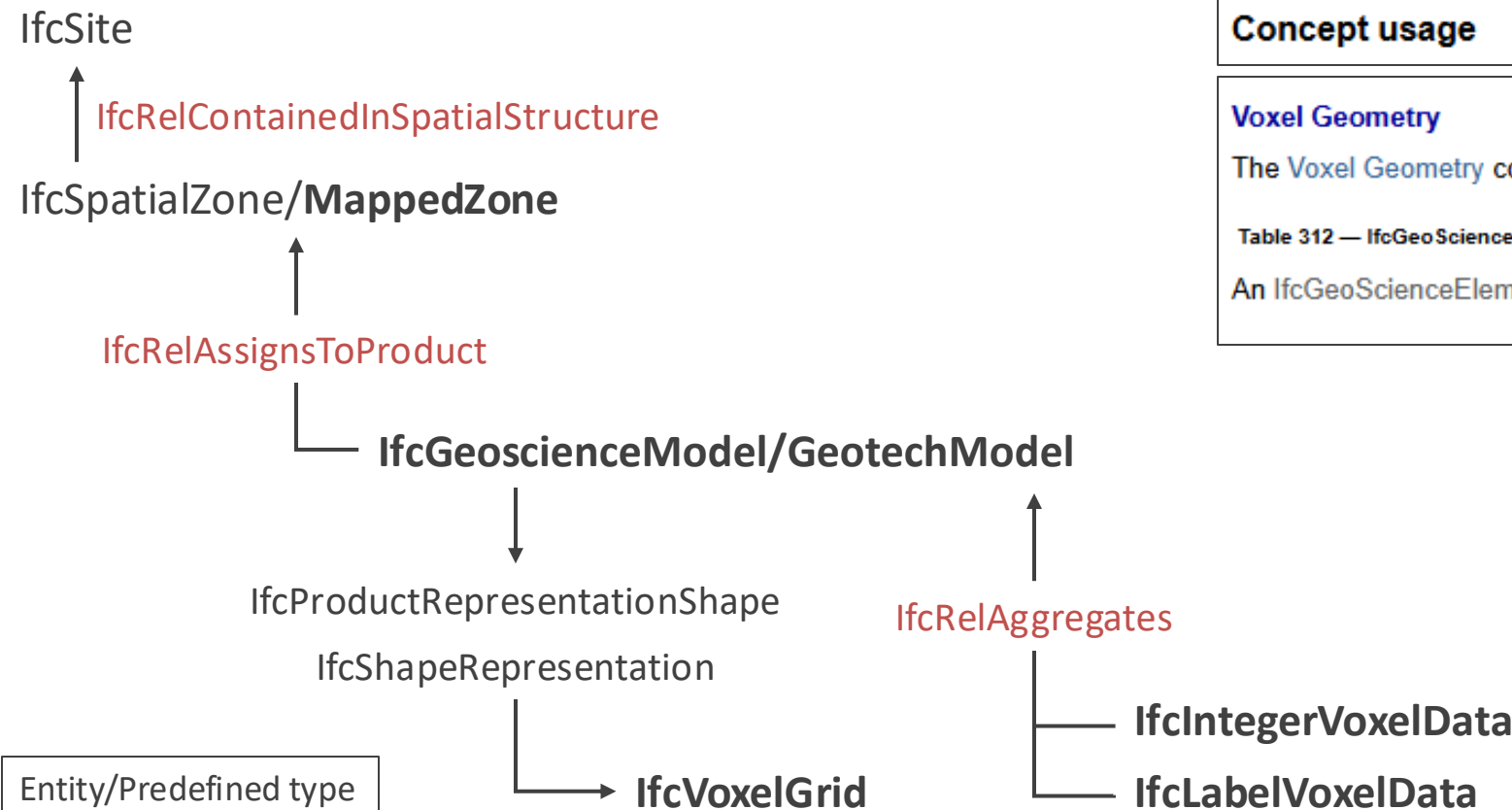


Data model – Voxel



Entity/Predefined type
Relationship
Property set
Bold: New in 4.4

Data model – Voxel



IfcGeoScienceElement

Concept usage

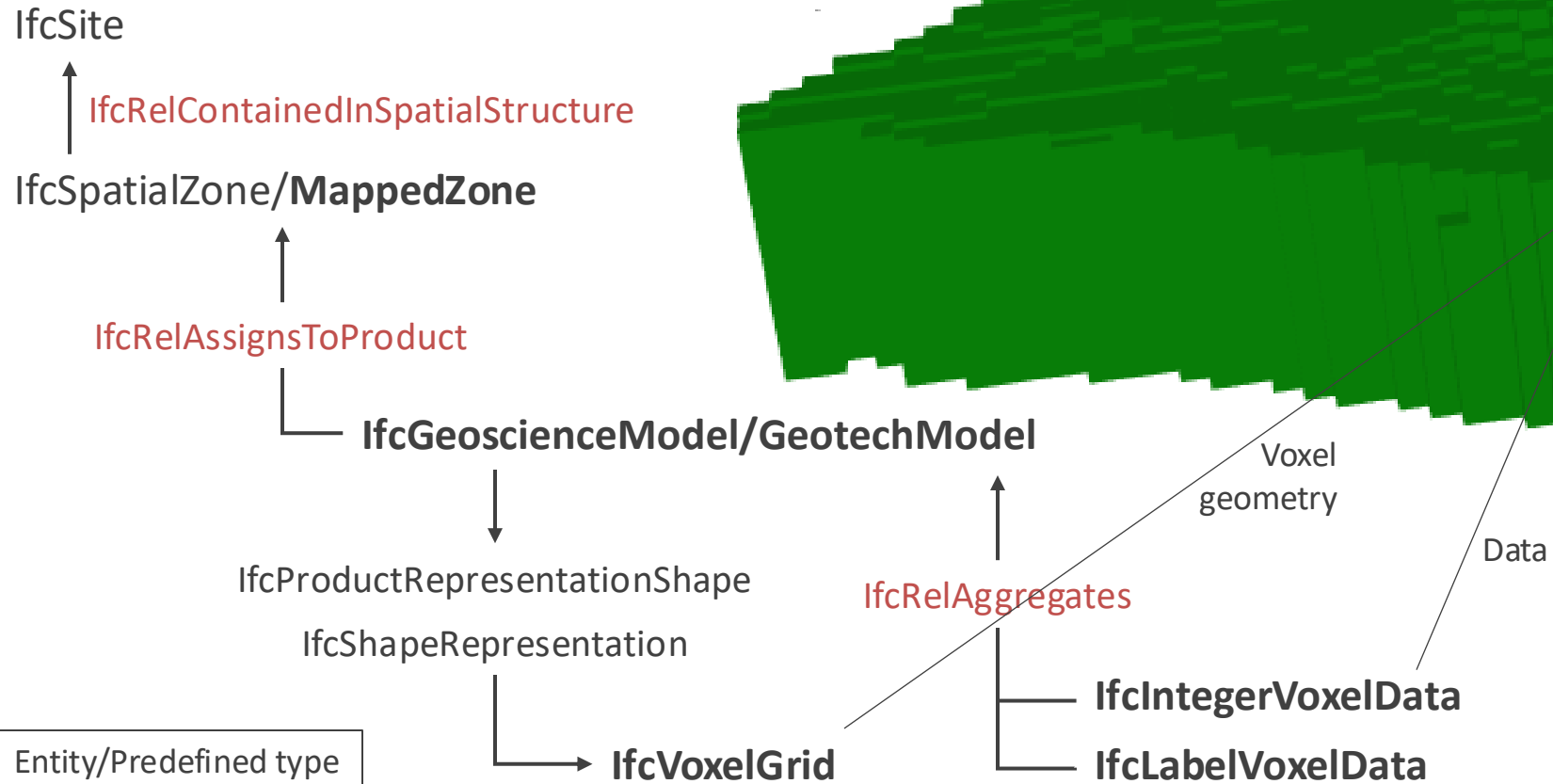
Voxel Geometry

The **Voxel Geometry** concept template applies to this entity as shown in Table 312.

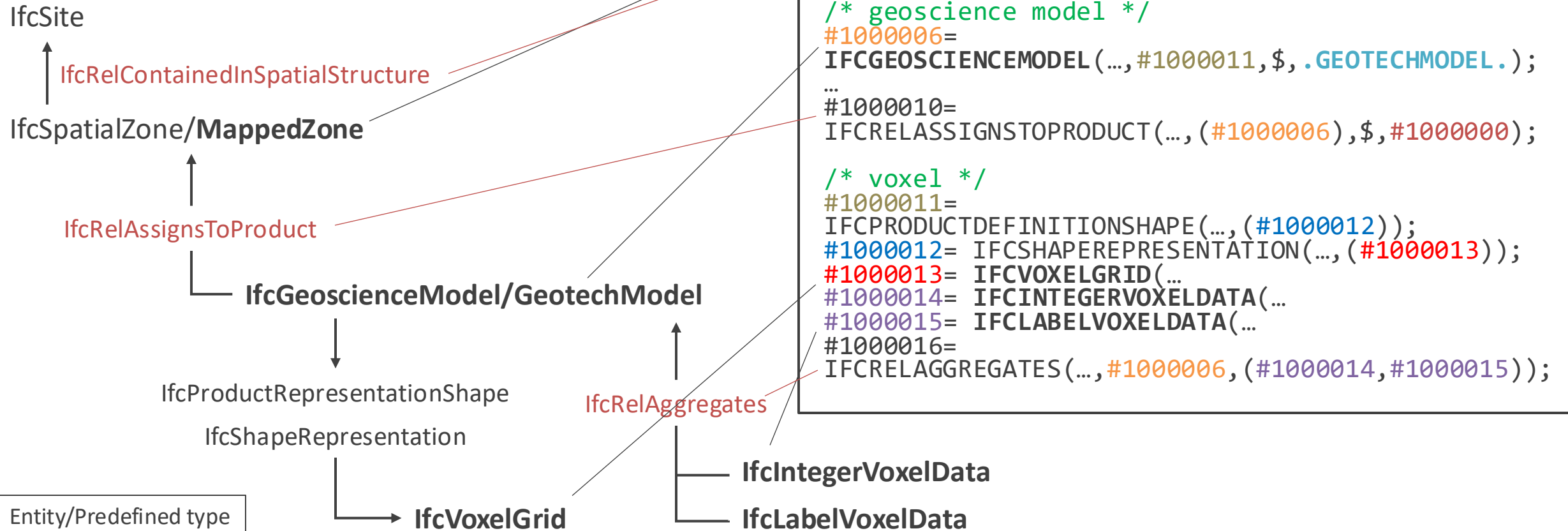
Table 312 — IfcGeoScienceElement Voxel Geometry

An IfcGeoScienceElement may be represented by an IfcVoxelGrid.

Data model – Voxel



Data model – Voxel



Entity/Predefined type
Relationship
Property set
Bold: New in 4.4

Summary

- Geological/geotechnical model of Central Tokyo
- Model encoded using IFC4.4
 - Using proposed entities and property sets
 - Retains geological and geotechnical information
 - Voxel models

⇒ Exchange of information for geotechnical risk analysis/evaluation became simple and easy
- IFC4.4 extension is useful for geotechnical projects
- Hope for the approval and publication by buildingSMART International soon

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Property sets for borehole logs

Pset_BoreholeCommon

BoreholeState

CapDepth

CapMaterial

FillingDepth

FillingMaterial

GroundwaterDepth

LiningMaterial

LiningThickness

Pset_GeoObsCommon

ObservationStartDate

ObservationEndDate

Lithology

Pset_InSituTestCommon

TestMethod

TestStandard

TestType

Pset_GeoObsBoreholeGeoLogInterval

GeologyCode

Weathering

FractureIndex

RockQualityDesignation

TotalCoreRecovery

SolidCoreRecovery

Pset_BoreholeTestSPT

NValue

YoungModulus

Property sets for sections

Pset_GeoscienceModelCommon

ModelUseCase

CreationDate

ReleaseDate

UpdateDate

VersionNumber

ModelPurpose

ModelStatus

Authors

Organizations

AreaOfInterest

Pset_GeoScienceFeatureTypeGeologicalUnit

GeologicUnitType

Rank

Lithology

GeologicHistory

RepresentativeAge

FaciesLithostratigraphy

FaciesPetrophysics

GeologicalHazard

Voxel geometry concept template

