New Survey Results of Archaeological Settlement Infrastructures and Holocene-prehistoric Volcanological Features

Based on Methodological Conceptual Multi-disciplinary Contextualisation

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Abstract—**This paper presents the new survey and methodological analysis results of the research on coherent multi-disciplinary contextualisation and symbolic representation of worldwide Holocene-prehistoric volcanological features and discovery of archaeological settlement infrastructures, especially for prehistoric contexts and context discovery. The research is based on methodological contextualisation and targets flexible context representation, processing, and integration, which includes further development of knowledge resources, visualisation, and chorological and chronological views for analysis, interpretation, decision making, and new insight. The presented practical implementation employs the new Conceptual Knowledge Reference Implementation (CKRI) and the Component Reference Implementations (CRI) framework for conceptual knowledge-based context integration, complements knowledge processing, and geoscientific and spatial processing and visualisation. The goal of this research is the creation of practical knowledge-based methods and tool set components, which provide solid, standardised means for sustainable long-term research. Both, methods and components should enable further continuous development and adoption to future research questions and targets. This paper provides the specific context discovery results, references to all component implementations and realisations based on coherent multi-disciplinary conceptual knowledge and methodological and systematical component integration. Future research will address further, continuous developments of reference implementations and knowledge resources and the application for advanced large scale scenarios, site surveys, and campaigns in prehistory and archaeology.**

***Keywords*–Prehistory; Holocene; Archaeological Settlement Infrastructures; Coherent Multi-disciplinary Conceptual Knowledge Contextualisation; CKRI and CRI Framework.**

I. Introduction

This paper is an extended and updated presentation of new research results, based on the research, publication, and presentation at the GEOProcessing 2023 conference in Venice, Italy [1].

The theoretical and practical developments of this ongoing research are one group of six impactful research endeavors selected worldwide for the 2023 Hyperion Research special report on recent High-Performance Computing (HPC) centric AI success stories [2] (AI, "Artificial Intelligence"). The special report emphasises the epistemologically relevant methodological fundament 'The Conceptual Knowledge Reference Implementation' (CKRI) and 'The Component Reference Implementations framework' (CRI), providing sustainable standard component groups for implementation.

Due to the large number of inquiries and far-reaching interests from scientific disciplines and public regarding multi-disciplinary contextualisation cases employing the created inventory, we take the chance that this extended paper can concentrate on the practical application of the inventory, showing a wider range of new survey and on-site result groups of archaeological settlement infrastructures and insights based on practical conceptual facets used for on-demand contextualisation and symbolic representation. The entirety of provided methods enables an advanced, consistent multi-disciplinary conceptual knowledge contextualisation, especially universal knowledge facets, method integration, flexible workflow definition, and parallelisation on HPC resources.

Both, the ongoing research on the epistemological [3] and the components base [4] and its implementations were published and demonstrated at the Lawrence Livermore National Laboratory (LLNL) [5].

This publication includes the new survey results and references to on-site results of archaeological settlement infrastructures and Holocene-prehistoric volcanological features based on methodological contextualisation. The historico-cultural contexts span several continents.

The goal of contextualisation especially targets prehistoric contexts worldwide, identifying and integrating archaeological, prehistoric objects with objects from other scientific disciplines on equal footing, promoting a coherent multi-disciplinary conceptual methodological approach. The methodological goal of this research is the creation of practical and sustainable knowledge-based methods and tool sets, which provide solid means for sustainable long-term research. The methods and sets of tools should provide standardised components, which can be continuously further developed and adopted to future research questions and targets. The research targets flexible context processing, integration, and representation, which includes further development of knowledge resources, visualisation, and chorological and chronological views for analysis, interpretation, decision making, and new insight.

The rest of this paper is organised as follows. Sections II and III present the implementations of and conceptual knowledge with all required references including all technical aspects. Section IV provides the all respective components and references used for implementation. Section V delivers results for an excerpt of four scenarios. Sections VI and VII discuss case scenarios and summarise lessons learned, conclusions, and future work.

II. Knowledge and Component Implementations

Two major practical reference implementations were deployed for full implementations, realisations, and continuous further developments: the new versions of the prehistory-protohistory and archaeology CKRI [3] and the CRI framework [4] for conceptual knowledge-based context integration, complements processing, and geoscientific visualisation. CKRI provides the knowledge framework, including multi-disciplinary contexts of natural sciences and humanities [6]. CRI provides the required component groups and components for the implementation and realisation of all the procedural modules.

The reference implementations are based on the fundamental methodology of knowledge complements [7], considering that many facets of knowledge, including prehistory, need to be continuously acquired and reviewed [8]. Creating contextualisation requires to coherently integrate multi-disciplinary knowledge and to enable symbolic representations. Realisations need to integrate a wide range of components as required from participating disciplines, e.g., for dynamical processing, geoprocessing, spatial contextualisation. The capabilities and features of both reference implementations are huge. The individual characteristics and features of the components are explained in detail in the cited publications and the referenced documentation of the components. The materials also already include thousands of examples and applications. Here, we will assume these fundaments to be known and concentrate on the newly achieved survey results of archaeological settlement infrastructures and Holocene-prehistoric volcanological features.

III. Conceptual Knowledge Implementation

Implementations and realisations are based on the CKRI reference implementation [9], and respective contextualisation. References are capable to integrate required context. Besides the core scope of this knowledge-focussed research on prehistoric, archaeological, and geoscientific questions, procedural complements are employed and extended via the CRI frame reference implementations [10]. Both provide sustainable fundaments for highest levels of reproducibility and standardisation.

Many aspects of knowledge [11], including meaning, can be described using knowledge complements supporting a modern definition of knowledge [12] and subsequent component instrumentation, e.g., considering factual, conceptual, procedural, metacognitive, and structural knowledge. Complements are a means of understanding and targeting new insight, e.g., enabling advanced contextualisation, integration, analysis, synthesis, innovation, prospection, and documentation. Regarding knowledge, it should be taken for granted, that scientific members of any disciplines nowadays continuously practice and train themselves in development and practical employment of methods, algorithms, and components as required by their disciplines and keep track with how to integrate methods.

A. *Coherent Conceptual Knowledge Implementation*

Universally coherent multi-disciplinary conceptual knowledge is implemented via the CKRI [9], demonstrated with Universal Decimal Classification (UDC) [13] code references, spanning the main tables [14], based on science and knowledge organisation [15], [16], as shown in Table I. The verbal descriptions of the references are already available in more than fifty languages. Here, verbal descriptions are given in English language (en) as is. Any factual content in the verbal descriptions can be deliberately modified and re-assigned if descriptions should be used in a procedure. Consistent multi-disciplinary conceptual knowledge is demonstrated via UDC code references spanning auxiliary tables [16].

Table I. CKRI Implementation of Coherent Conceptual Knowledge Contextualisation; Main Tables (excerpt).

Code / Sign Ref.	*Verbal Description (en)*
UDC:0	Science and Knowledge. Organization. Computer Science. Information. Documentation. Librarianship. Institutions. Publications
UDC:1	Philosophy. Psychology
UDC:2	Religion. Theology
UDC:3	Social Sciences
UDC:5	Mathematics. Natural Sciences
UDC:52	Astronomy. Astrophysics. Space research. Geodesy
UDC:53	Physics
UDC:539	Physical nature of matter
UDC:54	Chemistry. Crystallography. Mineralogy
UDC:55	Earth Sciences. Geological sciences
UDC:550.3	Geophysics
UDC:550.7	Geobiology. Geological actions of organisms
UDC:550.8	Applied geology and geophysics. Geological prospecting and exploration. Interpretation of results
UDC:551	General geology. Meteorology. Climatology. Historical geology. Stratigraphy. Palaeogeography
UDC:551.2…	Fumaroles. Solfataras. Geysers. Hot springs. Mofettes. Carbon dioxide vents. Soffioni
UDC:551.21	Vulcanicity. Vulcanism. Volcanoes. Eruptive phenomena. Eruptions
UDC:551.24	Geotectonics
UDC:551.4	Geomorphology. Study of the Earth's physical forms
UDC:551.44	Speleology. Caves. Fissures. Underground waters
UDC:551.46	Physical oceanography. Submarine topography. Ocean floor
UDC:551.7	Historical geology. Stratigraphy
UDC:551.8	Palaeogeography
UDC:56	Palaeontology
UDC:6	Applied Sciences. Medicine, Technology
UDC:63	Agriculture and related sciences and techniques. Forestry. Farming. Wildlife exploitation
UDC:631	Agriculture in general
UDC:631.4	Soil science. Pedology. Soil research
UDC:692	Structural parts and elements of buildings
UDC:7	The Arts. Entertainment. Sport
UDC:711	Principles and practice of physical planning. Regional, town and country planning
UDC:8	Linguistics. Literature
UDC:9	Geography. Biography. History
UDC:902	Archaeology
UDC:903	Prehistory. Prehistoric remains, artefacts, antiquities
UDC:904	Cultural remains of historical times

The excerpts span all main tables, including relevant references required for this research. The CKRI is provided in development stage editions, prehistory-protohistory and archaeology E.0.4.8, natural sciences E.0.4.0.

B. Implementation of Auxiliaries and Operations

Tables II and III show CKRI excerpts of auxiliary tables and signs. Geological time ranges are in Million Years Before Present (MYBP).

TABLE II. CKRI IMPLEMENTATION OF COHERENT CONCEPTUAL KNOWLEDGE CONTEXTUALISATION; AUXILIARY TABLES (EXCERPT).

Code / Sign Ref.	*Verbal Description (en)*
UDC (1/9)	Common auxiliaries of place
UDC:(1)	Place and space in general. Localization. Orientation
UDC:(2)	Physiographic designation
UDC:(23)	Above sea level. Surface relief. Above ground generally. Mountains
UDC:(24)	Below sea level. Underground. Subterranean
UDC:(3)	Places of the ancient and mediaeval world
UDC:(4/9)	Countries and places of the modern world
UDC:"..."	Common auxiliaries of time.
UDC:"6"	Geological, archaeological and cultural time divisions
UDC:"61"	Precambrian (more than 542 MYBP) (supereon)
UDC:"62"	Phanerozoic (542 MYBP to present) (eon)
UDC:"621"	Palaeozoic / Paleozoic (542-251 MYBP) (era)
UDC:"622"	Mesozoic (251-65.5 MYBP) (era)
UDC:"628"	Cenozoic (65.5 MYBP to present) (era)
UDC:"63"	Archaeological, prehistoric, protohistoric periods and ages

Standardised operations (Table III) are employed for creation of reference listings and facetted knowledge, integrating UDC auxiliary signs [16].

TABLE III. CKRI OPERATION SIGNS EXCERPT, INTEGRATING UDC COMMON AUXILIARY SIGNS (ENGLISH COMMENTS VERSION).

Operation	*Symbol*	
Coordination. Addition	+	(plus sign)
Consecutive extension	/	(oblique stroke sign)
Simple relation	:	(colon sign)
Order-fixing	::	(double colon sign)
Subgrouping	[]	(square brackets)
Introduces non-UDC notation	*	(asterisk)
Direct alphabetical specification.	A/Z	(alphabetic characters)
[Reference listing, itemisation]	;	(semicolon)
[Reference listing, sub-itemisation]	,	(comma)

Conceptual knowledge in focus can be employed to provide references and facets to any universal knowledge context.

IV. COMPONENT IMPLEMENTATIONS

A. Resulting Methodological Component Integration

Integration components, reflecting standards and sustainable modules are based on the major groups of the CRI. The CRI framework is provided in development stage edition E.0.3.9. The ten major CRI component groups are:

1) Conceptual knowledge frameworks.
2) Conceptual knowledge base.
3) Integration of scientific reference frameworks.
4) Formalisation.
5) Methodologies and workflows integration.
6) Prehistory knowledge resources.
7) Natural sciences knowledge resources.
8) Inherent representation groups.
9) Scientific context parametrisation.
10) Structures and symbolic representation.

All parts were realised based on CRI components, with realisations fully referenced in the following sections. The groups are numbered for clearly addressing that these components and the understanding of their functional requirements and also their technical background are precondition for own knowledge-centric implementations and realisations.

1) The conceptual knowledge was realised for all disciplines via the CKRI conceptual knowledge framework [9] and operations (Table III). CKRI is demonstrated with UDC [13] references. For demonstration, CKRI references are illustrated via the multi-lingual UDC summary [13] released by the UDC Consortium, Creative Commons licence [17].
2) Relevant scientific practices, frameworks, and standards from disciplines and contexts are integrated with the Knowledge Resources (KR), e.g., here details regarding volcanological features, chronologies, spatial information, and Volcanic Explosivity Index (VEI) [18]. Corresponding coherent complementary results and details on faceting are available for a whole inventory of volcanological features groups [3].
3) All integration components, for all disciplines, require an explicit and continuous formalisation [19] process. The formalisation includes computation model support, e.g., parallelisation standards, OpenMP [20], Reg Exp patterns, e.g., Perl Compatible Regular Expressions (PCRE) [21]. Here, common scale of entities for primary objects is 10^3 and for secondary objects 10^4–10^5. Processing operations [22] were parallelised for primary (n_1) features groups with respective instances. For production, all components were implemented under Linux on multi-core systems and showed very efficient, both for OpenMP and GNU Parallel (GNU, Gnu's Not Unix).
4) Methodologies for creating and utilising methods include model processing, remote sensing, spatial mapping, high information densities, and visualisation. Respective contextualisation for scenarios in prehistory should be done under conditions especially reflecting state-of-the-art methods, e.g., spatial operations, triangulation, gradient computation, and projection.
5) The symbolic representation of the contextualisation can be done with a wide range of methods, algorithms, and available components, e.g., implemented here via LX Professional Scientific Content-Context-Suite (LX PSCC Suite) deploying the Generic Mapping Tools (GMT) [22] for visualisation.
6) Prehistoric objects and contexts are taken from The Prehistory and Archaeology Knowledge Archive (PAKA), which is in continuous development for more than three decades [23], released by DIMF [24]. Collaborative interfaces, e.g., The Archaeological Data Collector (ADC) [25], were developed and established for archaeological survey contributions and are used for ongoing data integration and analysis.

7) Several coherent systems of major natural sciences' context object groups from KR realisations have been implemented, especially KR focussing on volcanological features [18] deployed with in depth contextualisation and with a wide range [13] of contexts [26] and structures [27] [28].
8) The contextualisation solution can employ state-of-the-art results from many disciplines, e.g., context from the natural sciences resources, integrating their inherent representation and common utilisation, e.g., points, polygons, lines, and spatial techniques and standards. Here, resources are Digital Elevation Models (DEM), High Resolution (HR) (Space) Shuttle Radar Topography Mission (SRTM) [29] data fusion [30], HR Digital Chart of the World (DCW) [31], and Global Self-consistent Hierarchical High-resolution Geography (GSHHG) [32].
9) Scientific context parametrisation of prehistoric targets can use the overall insight from all disciplines, e.g., parametrising algorithms and creating palaeolandscapes.
10) Structure is an organisation of interrelated entities in a material or non-material object or system [27]. Here, relevant examples of sustainable implementations are NetCDF [33] based standards, including advanced features, hybrid structure integration, and parallel computing support (PnetCDF).

Overall, all parts of the solution were implemented and realised via these components. Especially, GMT modules were deployed for select procedures together with PCRE and Perl filters. Spatial distance dependencies of objects and conditional decision criteria were realised via GMT geodesic calculation, which is very accurate using the Vincenty algorithm [34].

V. Scenarios, Implementations and Results

The results for a multi-disciplinary case scenario from the current research with full practical implementations for four primary case instances were chosen, Holocene-prehistoric volcanological features of strato volcanoes, maars, subglacial volcanoes, and submarine volcanoes (CKRI: UDC:511.2...), with geospherical calculations on a global scale and context discovery with coherently classified archaeological settlement infrastructure instances (CKRI: UDC:711....,692,903,902,...) in geospherical radii of 300 km spatial distance from primary objects.

A. Methodological Approach

The method can be summarised as follows.

- Selection of KR, components, primary and secondary object types, symbolic representation, ...
- Conceptual knowledge assignment.
- Selection of chronological properties.
- Selection of primary objects.
- Selection of secondary objects.
- Calculation of secondary objects' geospherical spatial distances.
- Parallelisation of conceptual knowledge processing.
- Parametrisation of symbolic representation.
- Parallelisation of context data processing.
- Visualisation processing.
- (Further development of resources and implementations by the specific disciplines.)

In new applications, all steps and items should be carefully and intentionally addressed for any intelligent employment, depending on the research questions and contexts.

B. Resulting Context Groups

An excerpt of the four primary context groups and criteria (@, β, γ, and δ) and contextualisation of archaeological settlement infrastructures is shown in (Table IV). The primary decision criteria (n_1) include conceptual context, feature object type, chronology, and position. The secondary decision criteria (n_2) include conceptual context, prehistoric object type, chronology, position, and conditional geospherical spatial distance depending on respective primary objects.

TABLE IV. SCENARIO CONTEXT GROUPS AND CRITERIA: VOLC. FEATURES / ARCH. SETTLEMENT INFRASTRUCTURES (EXCERPT).

Context n_1		*Context n_2*
Geosciences		Archaeology / prehistory
Geoscientific features objects		Prehistoric object groups
Volc. features groups		Settlement infrastructures
• **Strato volcano**	@ ⇒ {	• **Viereckschanze**
• Shield volcano		• **Dwelling**
• **Maar**	β ⇒ {	• **Long house**
• Complex volcano		• **Midden context**
• Explosion crater		• **Farm hut**
• **Subglacial volcano**	γ ⇒ {	• **Enclosure**
• **Submarine volcano**	δ ⇒ {	• **Roundhouse**
• Volcanic field		• **Siedlungsplatz**
• Cone		• **Homestead**
• Fissure vent		• **Hut circle**
• Dome		• **[individually named]**
• ...		• ...
[Type Instances ...]		[Type instances ...]
Decision Criteria (n_1)		*Decision Criteria (n_2)*
Conceptual context (CKRI)		Conceptual context (CKRI)
Feature object type		Prehistoric object type
Chronology conditions		Chronology conditions
Chorology / positional conditions		Chorology / positional conditions
Object attributes		Object attributes
...		Geospherical spatial distance
...		(n_1-instance-conditional)
...		Parametrisation, ...,
...		Calculation / analysis

Prehistoric object groups include all available language representations, e.g., 'en' and 'de'. Here, the first primary object group defines the spatial projection for consecutive primary groups. Each of these primary groups is contextualised for all of the secondary object groups.

C. Resulting Context Discovery Matrices

Table V shows an excerpt of the result matrix of Holocene-prehistoric volcanological features groups and respective facets, namely conceptual knowledge, chronology, and chorology for the four scenarios (@, β, γ, and δ in Table IV).

The result matrix includes conceptual knowledge view groups [13] based on CKRI references [9], factual knowledge from the KR objects, respective Country Codes (CC), and further Associated Context Data (ACD), e.g., symbolic representations of national flags.

Context example references for the features groups facets show Prehistoric Volcanic Activity (PVA), Historic Volcanic Activity (HVA), and Continued Volcanic Activity (CVA), e.g., latent volcanic activity. PVA are consequence of the Holocene-prehistoric chronological contextualisation for all objects in the resulting volcanological features groups. Cases for which further facts are holding true can also allow past-prehistoric contextualisation, e.g., with HVA and CVA.

Four instances each are further discussed for the primary scenarios. Contextualisation for instances is done regarding resulting settlement infrastructures. Instances are named ①, ②, ③, ④. Resulting context discovery matrices for primary case instances of the scenario for multi-disciplinary contextualisation of settlements are given in Tables VI and VII. Instances @, β, γ, and δ refer to Table IV. Figure 1 shows a corresponding visualisation of the calculation results of the context discovery for the first two instances.

The corresponding visualisation of the calculation results of the context discovery for consecutive instances three and four are given in Figure 2. Overall we have sixteen groups in this example as we select four primary with four secondary groups each. By consequently following the methodological approach does have the benefit of being consistent regarding multi-disciplinary conceptual knowledge, e.g., when integrating volcanological features and archaeological settlement infrastructures. The targets can also be modified by switching primary and secondary groups and by selecting different object groups. Applying such systematical implementations for the realisation of individual methods for case scenarios can deliver new factual answers to different research questions.

VI. Discussion of Case Scenario Results

The next sections discuss result we regard relevant from the methodological, historico-cultural, and educational domains.

A. Methodological Domain

Implementation and realisation provide a seamlessly coherent multi-disciplinary conceptual knowledge contextualisation for the case scenario and its instances. The context discovery result matrices (Tables VI, VII, VIII, and IX) for all instances @, β, γ, and δ refer to n_2 in Table IV. Especially, these secondary object groups include objects from Middle Neolithic (MN) to at least Late Iron Age (LIA), including ages in between, e.g., Bronze Age. Auxiliaries of time support various concepts and include geological, archaeological, and cultural time divisions, spanning from the Precambrian Supereon over the Archaean to the Palaeolithic over the Neolithic and to historical times. Mechanisms allow flexible extensions and facets, e.g., 'zoic' and 'phytic' references. Therefore, the Holocene-prehistoric scenarios, besides their high quantities and complexities, comprise just a small subset of cases.

The objects groups comprise all types of settlement infrastructures, e.g., Celtic ramparts, Viereckschanzen (VS), earthworks –commonly square, four corner ramparts–, and middens with settlement contexts.

The resulting group of strato volcanoes aligns along $0^\circ/360^\circ$ longitude (Figure 1). An appropriate Transverse Mercator projection was chosen in order to minimise the distortion along a respective meridian for the generation of the primary results of strato volcanoes and results for other consecutive, secondary, contextualised volcanological features, e.g., maars, subglacial and submarine volcanoes.

The CRI framework components were employed for all steps, including knowledge organisation, conceptual and spatial calculation, and visualisation. Primary objects, strato volcano (medium green volcano symbol), maars (light green volcano symbol), subglacial volcano (light cyan volcano symbol), and submarine volcano (cyan volcano symbol), are marked as well as resulting secondary objects, settlements (blue rectangular symbols), all in their precise georeferenced position. Resulting conceptual knowledge is given for these objects. Resulting sums of secondary discovery objects were calculated.

Each case scenario can be dynamically contextualised with coherent multi-disciplinary knowledge, as demonstrated for geosciences, prehistory, and archaeology, e.g., referring to prehistoric object properties and excavation results and targeting new insight from geoscientific and multi-disciplinary context integration.

Any resulting contextualisation matrices and coherent conceptual and facetted knowledge can further be input to consecutive contextualisation processes. The more, solutions with individual methods and workflows can be created for countless different questions and situations.

B. Historico-cultural Domain

The methodological approach to the cases delivers a series of new context-chorology results for our four scenarios:

Alpha-scenario: maximum numbers of archaeological settlement infrastructures in surrounding areas of strato volcanoes near the zero longitude are located in Japan, followed by Iceland, and the Azores, Portugal.

Beta-scenario: maximum numbers of archaeological settlement infrastructures in surrounding areas of maars under alpha-dependence conditions are located in the Eifel, Germany, followed by Chile, and Indonesia.

Gamma-scenario: maximum numbers of archaeological settlement infrastructures in surrounding areas of subglacial volcanoes under alpha-dependence conditions are located in Iceland and Canada.

Delta-scenario: maximum numbers of archaeological settlement infrastructures in surrounding areas of submarine volcanoes under alpha-dependence conditions are located in Italy and Iceland.

Integrated analysis: The methodological approach to the cases delivers further new results beyond the primary context groups, based on the large scale and on-site surveys. We see that the scenarios are interrelated on a knowledge level. The results form intermediate matrices from the KR, which can be used for further fact-based analysis, for which we just give some starting examples.

TABLE V. RESULT MATRIX OF HOLOCENE-PREHISTORIC VOLCANOLOGICAL FEATURES GROUPS FACETS (EXCERPT, @, β). IT INCLUDES CONCEPTUAL KNOWLEDGE VIEW GROUPS [13] (CKRI), VOLCANIC ACTIVITY, CONTEXTS, KNOWLEDGE RESOURCES OBJECTS, COUNTRY CODES (CC), AND FURTHER RESULTING ASSOCIATED CONTEXT DATA (ACD), E.G., SYMBOLIC REPRESENTATIONS (EXCERPT).

Multi-disciplinary Conceptual Knowledge Facets	*Chronology Facets*		*Chorology Facets*			*ACD*
Volcanological Features Conceptual Knowledge View / Facets Group	*Volcanic Activity*	*Context*	*KR Object & Ref.*		*CC*	*Flag*
CKRI: UDC:551.21,550.3,(23),STRATO_VOLCANO;“62”…	Holocene	PVA / HVA	Agua de Pau	1	PT	
CKRI: UDC:551.21,550.3,(23),STRATO_VOLCANO;“62”…	Holocene	PVA	Alngey	2	RU	
CKRI: UDC:551.21,550.3,(23),STRATO_VOLCANO;“62”…	Holocene	PVA / HVA	Azuma	3	JP	
CKRI: UDC:551.21,550.3,(23),STRATO_VOLCANO;“62”…	Holocene	PVA / HVA	Hekla	4	IS	
CKRI: UDC:551.21,550.3,(23),STRATO_VOLCANO;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.21,550.3,(23),SHIELD_VOLCANO;“62”…	Holocene	PVA / (CVA)	Volcán Darwin		EC	
CKRI: UDC:551.21,550.3,(23),SHIELD_VOLCANO;“62”…	Holocene	PVA / HVA	Kilauea		US	
CKRI: UDC:551.21,550.3,(23),SHIELD_VOLCANO;“62”…	Holocene	PVA / HVA	Santorini		GR	
CKRI: UDC:551.21,550.3,(23),SHIELD_VOLCANO;“62”…	Holocene	PVA	Waesche		AQ	
CKRI: UDC:551.21,550.3,(23),SHIELD_VOLCANO;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.2…,551.21,550.3,(23),…MAARS_FEATURES;“62”…	Holocene	PVA	Cerro Tujle	1	CL	
CKRI: UDC:551.2…,551.21,550.3,(23),…MAARS_FEATURES;“62”…	Holocene	PVA / HVA	Suoh	2	ID	
CKRI: UDC:551.2…,551.21,550.3,(23),…MAARS_FEATURES;“62”…	Holocene	PVA / HVA	Ukinrek Maars	3	US	
CKRI: UDC:551.2…,551.21,550.3,(23),…MAARS_FEATURES;“62”…	Holocene	PVA / (CVA)	West Eifel Volcanic Field	4	DE	
CKRI: UDC:551.2…,551.21,550.3,(23),…MAARS_FEATURES;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.21,550.2...,550.3,(23),COMPLEX_VOLCANO;“62”…	Holocene	PVA / HVA	Marapi		ID	
CKRI: UDC:551.21,550.2...,550.3,(23),COMPLEX_VOLCANO;“62”…	Holocene	PVA / HVA	Soretimeat		VU	
CKRI: UDC:551.21/550.2...,550.3,(23),COMPLEX_VOLCANO;“62”…	Holocene	PVA / HVA	Unzen		JP	
CKRI: UDC:551.21,550.2...,550.3,(23),COMPLEX_VOLCANO;“62”…	Holocene	PVA / HVA	Vesuvius		IT	
CKRI: UDC:551.21,550.2...,550.3,(23),COMPLEX_VOLCANO;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.21,550.3,(23),EXPLOSION_CRATER;“62”…	Holocene	PVA / (CVA)	Bunyaruguru Field		UG	
CKRI: UDC:551.21,550.3,(23),EXPLOSION_CRATER;“62”…	Holocene	PVA / HVA	Dallol		ET	
CKRI: UDC:551.21,550.3,(23),EXPLOSION_CRATER;“62”…	Holocene	PVA	Koranga		PG	
CKRI: UDC:551.21,550.3,(23),EXPLOSION_CRATER;“62”…	Holocene	PVA	San Luis Gonzaga, Isla		MX	
CKRI: UDC:551.21,550.3,(23),EXPLOSION_CRATER;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.21,550.3,(24)::551.32,SUBGLACIAL_VOLC...;“62”…	Holocene	PVA	Hoodoo Mountain	1	CA	
CKRI: UDC:551.21,550.3,(24)::551.32,SUBGLACIAL_VOLC...;“62”…	Holocene	PVA / HVA	Katla	2	IS	
CKRI: UDC:551.21,550.3,(24)::551.32,SUBGLACIAL_VOLC...;“62”…	Holocene	PVA / HVA	Loki-Fögrufjöll	3	IS	
CKRI: UDC:551.21,550.3,(24)::551.32,SUBGLACIAL_VOLC...;“62”…	Holocene	PVA / HVA	Volcan Viedma	4	AR	
CKRI: UDC:551.21,550.3,(24)::551.32,SUBGLACIAL_VOLC...;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.21,550.3,(24),SUBMARINE_VOLCANO;“62”…	Holocene	PVA / HVA	Campi Flegrei Mar Sicilia	1	IT	
CKRI: UDC:551.21,550.3,(24),SUBMARINE_VOLCANO;“62”…	Holocene	PVA / HVA	Curacoa	2	TO	
CKRI: UDC:551.21,550.3,(24),SUBMARINE_VOLCANO;“62”…	Holocene	PVA / HVA	Shin-Iwo-Jima	3	JP	
CKRI: UDC:551.21,550.3,(24),SUBMARINE_VOLCANO;“62”…	Holocene	PVA / HVA	Vestmannaeyjar	4	IS	
CKRI: UDC:551.21,550.3,(24),SUBMARINE_VOLCANO;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.23,551.21,550.3,(23),VOLCANIC_FIELD;“62”…	Holocene	PVA	Four Craters Lava Field		US	
CKRI: UDC:551.23,551.21,550.3,(23),VOLCANIC_FIELD;“62”…	Holocene	PVA	Gallego		SB	
CKRI: UDC:551.23,551.21,550.3,(23),VOLCANIC_FIELD;“62”…	Holocene	PVA / HVA	Volcán de San Antonio		ES	
CKRI: UDC:551.23,551.21,550.3,(23),VOLCANIC_FIELD;“62”…	Holocene	PVA	Volcán de Flores		GT	
CKRI: UDC:551.23,551.21,550.3,(23),VOLCANIC_FIELD;“62”…	Holocene	PVA	…		…	…
CKRI: UDC:551.21,550.3,(23),CONES;“62”…	Holocene	PVA	Bus-Obo		MN	
CKRI: UDC:551.21,550.3,(23),CONES;“62”…	Holocene	PVA	Kabargin Oth Group		GE	
CKRI: UDC:551.21,550.3,(23),CONES;“62”…	Holocene	PVA	Tore		PG	
CKRI: UDC:551.21,550.3,(23),CONES;“62”…	Holocene	PVA	Tutuila		AS	
CKRI: UDC:551.21,550.3,(23),CONES;“62”…	Holocene	PVA	…		…	…
…	…	…	…		…	…

The density of archaeological settlement infrastructures in the Eifel, Germany, is far highest. This area marks the southern margin of the North European Plain. The prehistoric extension of the North European Plain was several times larger than today.

Nevertheless, the Eifel also marks the southern margin of known occurrences of volcanological features in the periphery of the North European Plain during human presence in the prehistoric North European Plain in at least more than the last 700,000 years [35].

The resulting findings also show prevalent concentrations of archaeologically relevant settlement infrastructures in close proximity of otherwise historico-culturally used areas with high concentrations of volcanological feature groups with a wide diversity of volcanological features.

This is especially relevant for the settlement infrastructure

TABLE VI. RESULTING SETTLEMENT INFRASTRUCTURES FROM CONTEXTUALISATION WITH HOLOCENE-PREHISTORIC STRATO VOLCANO @ VOLCANOLOGICAL FEATURES GROUP (EXCERPT), INCLUDING CONCEPTUAL KNOWLEDGE VIEW GROUPS [13] (CKRI).

Multi-disciplinary Conceptual Knowledge Facets	*Chronology Facets*		*Chorology Facets*		
Prehistorical Conceptual Knowledge View / Facets Group	*Dependency*	*Context*	*Knowledge Resources Object*	*Count*	*Ref. & Range*
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Grota do Medo	$\sum = 1$	① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	–	$\sum = 0$	② 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Goshono		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Hotta-no Saku		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Kanai Higashiura		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Kiwa-no Saku		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Sakiyama Kaizuka		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Togariishi		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Yaze		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	...	$\sum = 14$	③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Flókatóftir		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Þjóðveldisbærinn		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Vogur		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Stöðvarfjörður	$\sum = 4$	④ 300 km

TABLE VII. RESULTING SETTLEMENT INFRASTRUCTURES FROM CONTEXTUALISATION WITH HOLOCENE-PREHISTORIC MAARS β VOLCANOLOGICAL FEATURES GROUP (EXCERPT), INCLUDING CONCEPTUAL KNOWLEDGE VIEW GROUPS [13] (CKRI).

Multi-disciplinary Conceptual Knowledge Facets	*Chronology Facets*		*Chorology Facets*		
Prehistorical Conceptual Knowledge View / Facets Group	*Dependency*	*Context*	*Knowledge Resources Object*	*Count*	*Ref. & Range*
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Bogatta		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Coctaca		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	La Huerta		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Los Armarillos		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Mariscal		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Potrero de Payogasta		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Pucará de Tilcara		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Tulor	$\sum = 8$	① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Segayun megalithic site	$\sum = 1$	② 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	–	$\sum = 0$	③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Benzenberg VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Bildechingen VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Burg Keltische VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Erbach VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Esslingen VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Federlesmahd VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Gelbrunn Wald VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Hardheim VS		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	...	$\sum = 180$	④ 300 km

results on Iceland, which show uniquely high concentration of settlement placements in a range of three volcanological feature groups, next to a diversity of strato volcanoes, subglacial volcanoes, and submarine volcanoes. The analysis results quantify and qualify the important role of these locations for ancient society, may it be have been for logistics, economy, and strategic purposes. The spatial density of the settlement can be suggested in this map scale but we have seen the detailed results in Tables VI, VIII, VII, and IX.

Further relevant context result from findings of prehistoric coast lines, especially for the prehistoric North European Plain. Factual prehistoric evidence in the prehistoric catchment ares of the North European Plain proves that findings concentrations date far back beyond Holocene, e.g., in England / Scotland so far 700,000 a to 500,000 a B.C.E (B.C.E., Before Common Era) for flint artefacts [35] and currently known 8,000 a to 7,800 a B.C.E. for post-built mesolithic houses [36] of post-glacial European societies. A large number of prehistoric settlements should still be waiting discovery and analysis in the prehistoric North European Plain, most of them in what are now submarine areas.

The results of the analysis in these scenarios enable us to further contextualise with physical and non-physical contexts supported by participating disciplines, e.g., targeting prehistoric use of resources and materials, ritual and symbolic correlations. Therefore, examples of object groups include findings of flint, obsidian, and basalt objects and material sources on the one hand and symbolic and mythological contexts on the other hand.

Regarding this long-term research, further findings from multi-disciplinary scientific endeavors are ongoing matter of research and contextualisation, especially pedology and soil condition results, bog and swamp related results, pre-modern mobility findings, findings on open field names and site names, coast lines, findings on materials of non-volcanic and volcanic origin, flint, obsidian, and basalt, and further volcanological

TABLE VIII. RESULTING SETTLEMENT INFRASTRUCTURES FROM CONTEXTUALISATION WITH HOLOCENE-PREHISTORIC SUBGLACIAL ⑦ VOLCANOLOGICAL FEATURES GROUP (EXCERPT), INCLUDING CONCEPTUAL KNOWLEDGE VIEW GROUPS [13] (CKRI).

Multi-disciplinary Conceptual Knowledge Facets	*Chronology Facets*		*Chorology Facets*		
Prehistorical Conceptual Knowledge View / Facets Group	*Dependency*	*Context*	*Knowledge Resources Object*	*Count*	*Ref. & Range*
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Lucy Islands		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Hidden Falls	$\sum = 2$	① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Flókatóftir		② 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Þjóðveldisbærinn		② 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Vogur		② 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Stöðvarfjörður	$\sum = 4$	② 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Flókatóftir		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Þjóðveldisbærinn		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Vogur		③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Stöðvarfjörður	$\sum = 4$	③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	–	$\sum = 0$	④ 300 km

TABLE IX. RESULTING SETTLEMENT INFRASTRUCTURES FROM CONTEXTUALISATION WITH HOLOCENE-PREHISTORIC SUBMARINE ⑧ VOLCANOLOGICAL FEATURES GROUP (EXCERPT), INCLUDING CONCEPTUAL KNOWLEDGE VIEW GROUPS [13] (CKRI).

Multi-disciplinary Conceptual Knowledge Facets	*Chronology Facets*		*Chorology Facets*		
Prehistorical Conceptual Knowledge View / Facets Group	*Dependency*	*Context*	*Knowledge Resources Object*	*Count*	*Ref. & Range*
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Bagni Greci		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Heraclea Minoa		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Lampedusa		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Megara Hyblaea		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Segesta		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Carthage Magon Quarter		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Hadrumet		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Kerkouane		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Neapolis (Nabeul)		① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	...	$\sum = 57$	① 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	–	$\sum = 0$	② 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	–	$\sum = 0$	③ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Flókatóftir		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Þjóðveldisbærinn		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Vogur		④ 300 km
CKRI: UDC:711....,692,903,902,SETTLEMENT_INFRASTRUCTURE;...	Synchronous	MN-LIA	Stöðvarfjörður	$\sum = 4$	④ 300 km

results, seismological results, and evidences of earthquakes and natural disasters in prehistoric times.

The knowledge resources associate context, e.g., from the fact that obsidian formation is associated with felsic lava and contains higher percentages of lighter elements, especially, Si, Al, Na, K, O (silicon, aluminium, sodium, potassium, oxygen). This makes it distinct from flint and basalt and allows historico-cultural contextualisations, e.g., origins of resources, travel, transport, and trade.

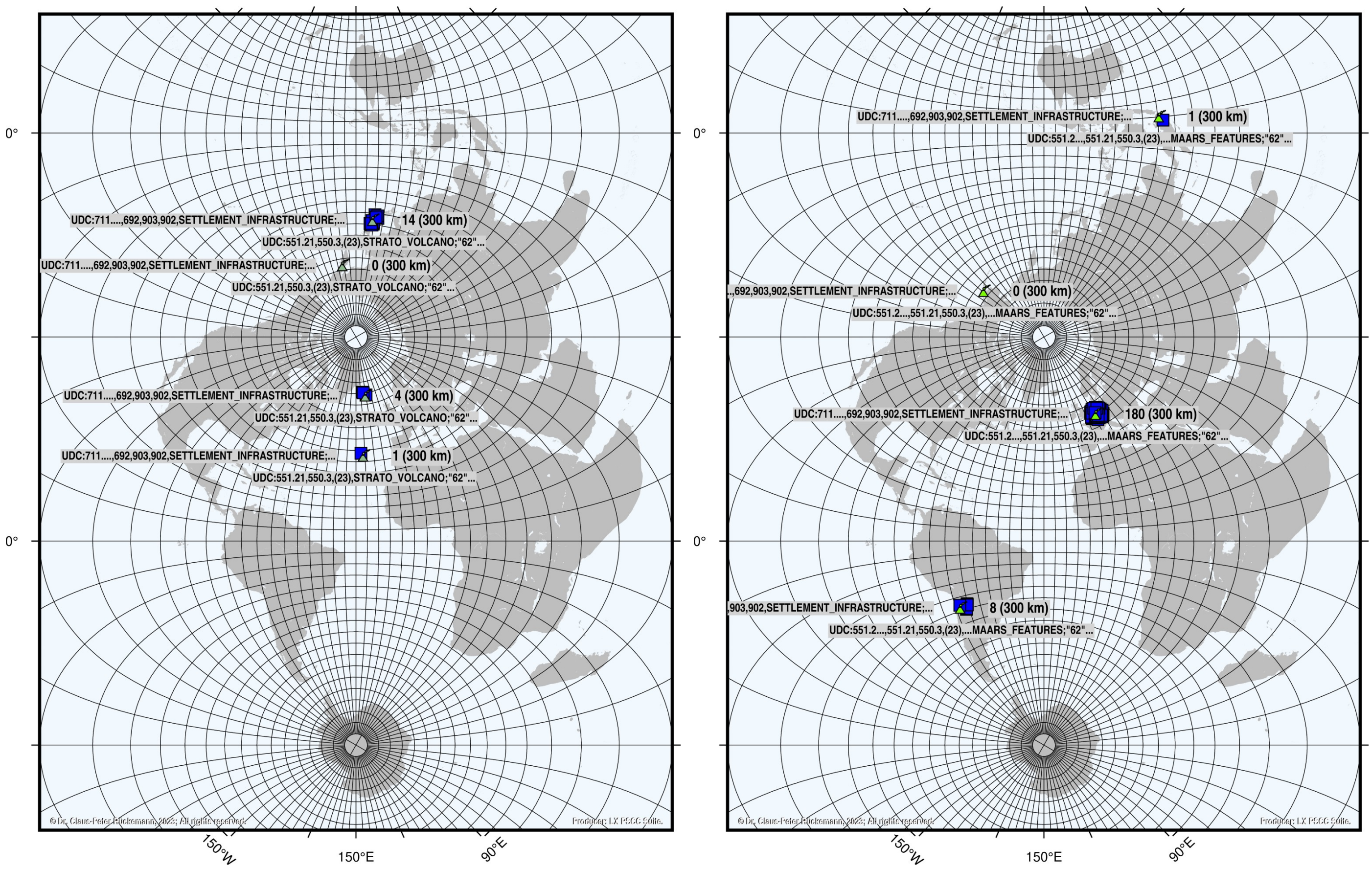
An example of multi-disciplinary contextualisation are factual results on pre-modern infrastructures, e.g., various pre-modern trackway systems, often wooden structures, are widely spread in several areas of interest, especially in the North European Plain, dating back older than 4,500 a B.C.E. [24], [37] [38] [39]. This is an example where results and insights –as often presented [40]– could benefit from a consequent scientific multi-disciplinary factual contextualisation in order to encounter non-factual approaches and perception.

C. Lessons Learned on Complexity and Educational Aspects

The methodology enables to manage a high grade of complexity and employ complexity for the creation of new insights. The methodological approach enables to even coherently contextualise symbolic, non-physical contexts of physical object groups by integrating new methods for procedural and conceptual knowledge complements, e.g., The Abydos Ships Method, a new insight-driven numeral systems approach for coherent multi-disciplinary analysis and contextualisation of object groups and their contexts [41].

The approach of methodological coherent multi-disciplinary contextualisation is what truly earns the term 'Artificial Instruments'. As all the 'technical' details are published and laid out in the given documentation of the components we have to explicitly emphasise that here a technical and unknowingly applied approach should not be considered a solution. This is just an optional consecutive stage of implementation and realisation as shown with the contextualisation here.

Contrary to an instrument approach, recently, researchers of some disciplines commented in personal communication that the motivation they use 'Artificial Intelligence' is that they do not want to lose the overview in their disciplines and respective contexts and because they want to get on in complex situations. This shows very limited engagements, shuffled views, and perspectives in some disciplines and is made an easy choice fostered by parts of the non-scientific world,



(a) Strato volcano group @: resulting archaeological settlement infrastructures.

(b) Maars group ⓑ: resulting archaeological settlement infrastructures.

Figure 1. Contextualisation: Holocene-prehistoric volcanological features groups for case scenarios one and two and the resulting settlement infrastructures. Coherent multi-disciplinary context integration and results based on CKRI, chronological, and chorological criteria (excerpts, Transverse Mercator projections).

by legal visions, and industry focus and is clearly not what we should want, especially not in science. Besides unfunded claims and neologisms, relevant fundamental principles have not changed, e.g., Turing machines [42], Busy Beaver test [43], and machine unintelligence [44]. It is for sure, these principles, logic, and consequences will prevail true, even in future.

The given conditions for determination and analysis of this scenario are independent from the symbolic representation, e.g., the visualisation. For example, the specification of a radius inside which we analyse archaeological settlement infrastructures does not represent archaeological object distributions. It is a common premise that researchers understand how to specify their research questions and how to describe and use their methods, premises, and relevant logic.

Therefore, from our experiences, it is recommended to include information science fundaments, e.g., epistemology and logic, during all stages of educational processes of all disciplines and to practice multi-disciplinary approaches. Comprehensive studies of the works of the classical Organon [45] [46] [47] [48] [49] and understanding of logical fallacies [50] can be most beneficial as starting points. Further, a few years of practical experience in employing the component groups in complex scenarios will also be helpful.

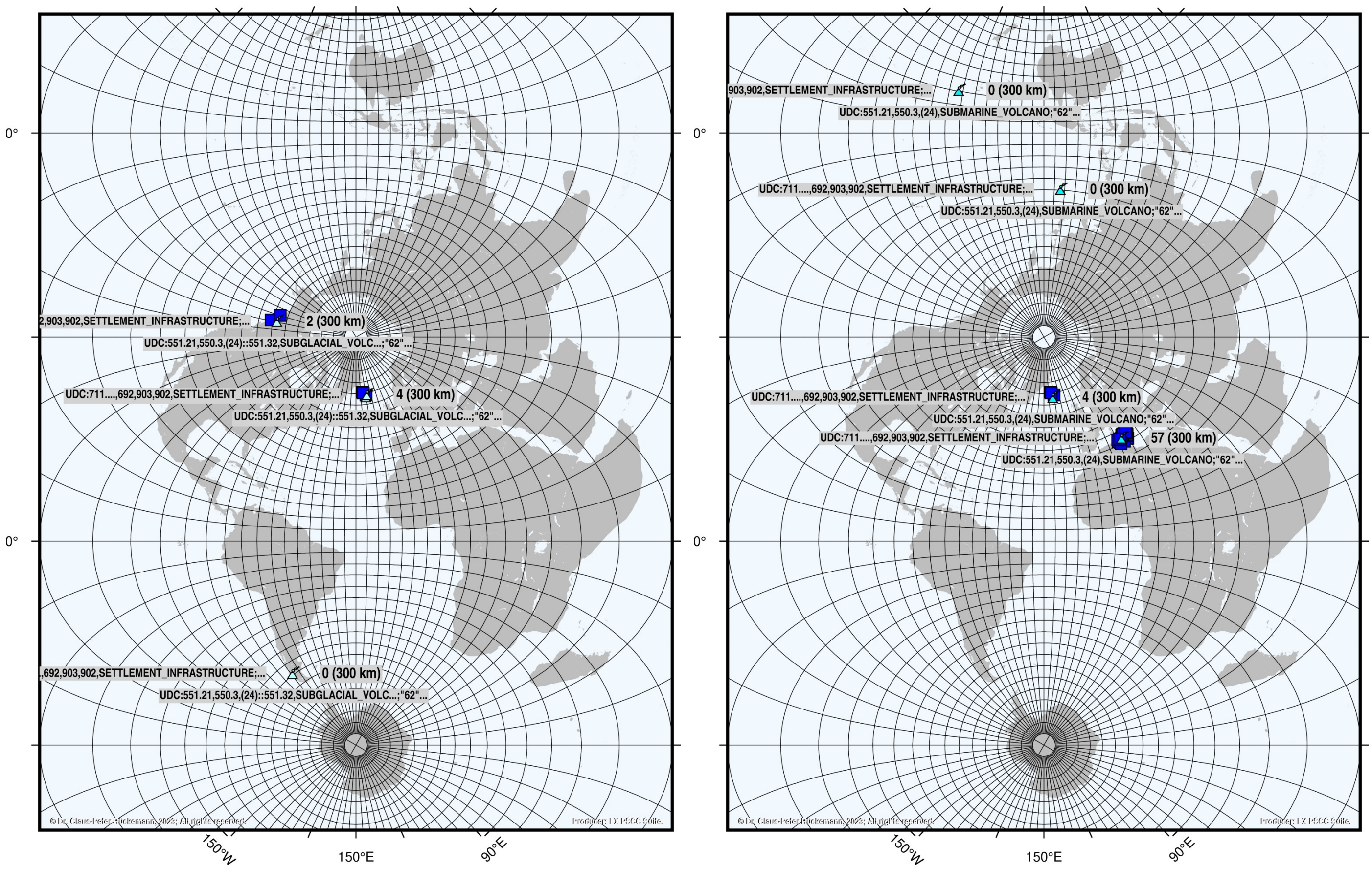
VII. Conclusion

This publication on extended research presented the new survey and methodological analysis results on coherent multi-disciplinary contextualisation and symbolic representation of worldwide Holocene-prehistoric volcanological features and discovery of archaeological settlement infrastructures, especially for prehistoric contexts and context discovery.

The research is based on the employment of contextualisation reference implementation and component frameworks for coherent multi-disciplinary conceptual knowledge-spatial context discovery, CKRI, which enable to implement conceptual multi-disciplinary coherency and a high level of consistency – keys for fact-based analysis and context correlation.

The practical realisations achieved their goals and proved efficient and sustainable over the long-term research and development of more than three decades. The case scenarios for context discovery of archaeological settlement infrastructures for Holocene-prehistoric volcanological features resulted in valuable contextualisation potential and possible new insight from on multi-disciplinary scenarios. The scenarios should have implicitly demonstrated that solely technical and procedural approaches are not sufficient.

The contextualisation integrates conceptual, factual, procedural, structural, and metacognitive knowledge complements. Based on the methodological approach, complements can be



(a) Subglacial volcano group ⓖ: resulting archaeol. settlement infrastructures. (b) Submarine volcano group ⓓ: resulting archaeol. settlement infrastructures.

Figure 2. Contextualisation: Holocene-prehistoric volcanological features groups for case scenarios three and four and the resulting settlement infrastructures. Coherent multi-disciplinary context integration and results based on CKRI, chronological, and chorological criteria (excerpts, Transverse Mercator projections).

identified and assigned during the contextualisation processes. An excerpt of complements relevant for this case scenario are CKRI classification, position data, calculation algorithms, content structures, and parametrisation experiences.

The methods and reference implementations can be efficiently and effectively employed for practical implementations and realisations for multi-disciplinary research, especially in prehistory, archaeology, natural sciences, and humanities. The solutions provide countless facilities and modules for adopting to individual solutions.

Future research will address archaeological settlement infrastructures and further object groups and new models for their coherent multi-disciplinary contextualisation based on continuous developments of the reference implementations and knowledge resources. Further, contextualisation and analysis of object groups will be matter of future advanced large scale scenarios, site surveys, and campaigns in prehistory and archaeology, targeting fact-based analysis and historico-cultural contexts. Projects will include ongoing multi-disciplinary investigations, e.g., context artefacts, pedological properties, soil characteristics, and pre-modern transport and mobility. The creation of new methods will include further integration and processing of knowledge complements, georeferencing, spatial and satellite data processing.

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