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Results of the Conceptual Knowledge Analysis of New Surveys and Campaigns on Prehistoric Volcanological Features' and Prehistoric Settlements' Agglomerations

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Abstract: The publication of this work delivers results of the conceptual knowledge analysis of new surveys, campaigns, and on-site studies on prehistoric volcanological features and prehistoric settlement infrastructure agglomerations in Europe, especially the Eifel and the Auvergne. The practical methodological approach employs latest 'The Conceptual Knowledge Reference Implementation (CKRI)' addressing knowledge complements and analysis, 'The Component Reference Implementations (CRI) framework' editions, which enables to integrate the required knowledge facilities, esp. conceptual and procedural, e.g., algorithms, for numerical computation and analysis for component implementations and realisations. Goal is to conduct further multi-disciplinary archaeology field surveys and research on objects and scenarios, deliver new historico-cultural insights from multi-disciplinary coherent contextualisation. The methodology enables to coherently integrate numerical methods. Methodologies, consecutive insights, and future research were presented and discussed in the keynote "Coherency, Consistency, Continuity, Conceptual Complement, and Contextualisation in Knowledge Models" and the "Delegates' Summit on Best Practice and Definitions", Sept. 16, 2025.

Keywords: Prehistory and Archaeology; Auvergne and Eifel; Numerical and Knowledge Analysis; Industrial Application; Information Science; Settlements and Volcanological Features; Multi-disciplinary Coherent Conceptual Knowledge; CKRI; CRI.

Mathematics Subject Classification: 03; 65; 86; 92; 97.

PACS: 01.00.00; 89.70.+c; 02.70.Hm; 93.85.Bc; 92.00.00; 92.60.Aa.

1 Introduction, Motivation, and Assigned Knowledge

In this publication, part of the Proc. ICNAAM 2025, we present a comprehensive epitomic summary of 'unprecedented' new scientific research results, insights, and advanced methods achieved,

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presented, and discussed at the SACINAS symposium series and the respective annual Delegates' Summit on Best Practice and Definitions of Knowledge at ICNAAM 2025, Heraklion, Crete, Greece.

The presented results are based on recent methodological approaches, multi-disciplinary research, on-site studies and campaigns, measurements, contextualisations and analysis results, which motivated extended research together with demands from researchers in associated disciplines.

The results comprise research between Eifel, Germany (DE), Luxembourg (LU), and Massif Central, France (FR) regions [1], archaeological and volcanological survey results [2, 3, 4, 5], context discovery [6], fact-based multi-disciplinary coherent conceptual contextualisation [1], faceting knowledge and context integration in prehistory and archaeology [7], and systematic long-term contextualisation approaches [8, 9, 10, 11, 12, 13]. The analysis results, based on factual knowledge, simplistically called 'data', implementations referring conceptual knowledge, target prehistoric volcanological features (bifurcation α) and prehistoric settlement infrastructures (bifurcation β) [14], especially for demonstration with this research

- CKRI: UDC:551.2...,551.21,550.3,(23);62::711....,692,903,902 and
- CKRI: UDC:167/168...;51...::711....,692,903,902.

Assigned keywords and conceptual knowledge for this research are {Prehistory; Archaeology; Auvergne; Eifel; Information Science; Settlements; Volcanological Features; Multi-disciplinary Coherent Conceptual Knowledge; CKRI; CRI}, PACS {01.00.00, 89.70.+c, 02.70.Hm, 93.85.Bc, 92.00.00, 92.60.Aa}, and CKRI: UDC:{902/904, (44), (430), 55, 72...., 0, 001, 001.891, 55, 912, 911.2, 004, 004.01, 004.62, 001.92, 021, 165.5, (0.034)}. Paper / materials were received 2025-02-28, submitted for peer review 2025-04-09, accepted for publication 2025-05-18, publicly presented, and discussed at the international scientific forum 2025-09-16.

1.1 Proem: Numerical Computation in Context of Advanced Knowledge Analysis

This section was added to support readers new to methodological numerical calculations involving advanced knowledge analysis, including knowledge complements and information science fundaments. Nevertheless, the following passages are no substitute for reading and understanding the content of the referenced publications and works employed and cited for this research. This contribution content was accepted for publication by 6 of 6 independent specialist peer reviews, presented and publicly discussed at the official international forum. This section respectfully addresses additional questions. The core target and insights of this research can neither be understood nor demonstrated from an isolated discipline or algorithmic view only. The disciplinary alignment of the application case towards prehistoric and protohistoric archaeology cases is funded on the nonpareil situation of its multi-disciplinary conditions required to achieve results in these disciplines. These examples provide straightforward implementations as demonstrated here. For other readers, advanced in the topics, may skip these proem passages, consider them commonplaces, and continue on the central knowledge focus itself with the new methods, results, and insights.

1.1.1 Sub-proem: Numerical Approaches and Factual Knowledge Realised as Components

The tasks required for achieving solutions in these contexts, beyond the focus of this research publication can employ a large set of numerical approaches working together. An extensive introduction, mathematical algorithms, including examples, is given with respective modular realisations [15] and new numerical analysis tasks, comprising theoretical and practical fundaments of major numerical calculations, depending on contextualisation and analysis focus (see published algorithms), e.g.:

- gradient calculations, e.g., on satellite and remote sensing data [15],
- regression and trend methods, especially spatial [15],

- triangulation methods, especially spatial [15],
- projection calculation, especially spatial [15],
- interpolation and extrapolation of structures [15],
- chorological and chronological calculations, e.g., for hypsography [15], and further
- parallelisation of processes [15], e.g., for workflows in participating disciplines,
- seismic processing, analysis, e.g., 'Superstack' stacking algorithms with 'layer' hypsometry,
- complex numerical analysis, e.g., from 'Fresnel Sections' to 'CONTFACT' algorithms,
- advanced structure and symbolism detection methods and respective algorithms, e.g., the numeral systems approach of 'The Abydos Ships Method' [13] or trackway slope angle calculation, discretisation, and contextualisation, ...

Examples of practically employed factual knowledge, data realisations, are satellite data and vector data, in their intrinsic representations of standard hybrid and xyz formats [16, 17, 18, 19].

The context knowledge for this research employs respective computation depending on the nature of the respective representations, especially projections and complex geodesic calculations. This work employs Mercator projections for demonstration, as the visualisation of satellite data is not required and an interpretation out of scope here. The long-term projects employ complex projections [20], geospherical calculations, geodesic distances and the Vincenty method [21], and equal area projections and azimuthal equidistant projections for analysis.

Many case relevant regressions have been conducted for knowledge in recent research, depending of the research focus of contextualisations and context analysis. This work employs linear regression for demonstration. The types are not relevant for the understanding of the creation and processing of the knowledge facets and analysis. The accompanied calculations on the data, not shown here, employ spatial regressions [15]. Especially, the analysis for each object groups includes Lasso Regularization (L_1, mean of absolute residuals), Ridge Regularization (L_2, mean of squared residuals), and Least Median of the Squared residuals (LMS), for latitude on longitude, longitude on latitude, orthogonal, and Reduced Major Axis (RMA) [15]. The components allow calculating Least Squares (LS) and Reweighted Least Squares (RLS) [15]. The results are out of scope here and will be published with the analysis of contextualisation in a separate extensive publication already to be published. The statistical results a given for comparison and future trend analysis. Error margins are statistically not relevant for understanding of the knowledge analysis here.

Understanding the concept of numbers is one aspect of the matter of understanding the concept of knowledge. Any method, scientific contexts, and implementation module should be understood before going into further detail before assigning knowledge facets for employment. The knowledge analysis in this research employs standard CKRI operations, esp. '`,`' and '`;`' operations.

1.1.2 Sub-proem: Essential Knowledge Resources, Reference Implementations, and Industry

It is not the intention of this research to provide an introduction to all numerical tasks, however advanced, as not relevant for the understanding of the research presented in this work. Each factual, conceptual, procedural, metacognitive, and structural entities within all processes in inherently attributed to respective knowledge facets. These knowledge facets should be kept intact during all numerical calculations and operations, including the subset of the above mentioned methods. In simplistic terms, this is comparable to complex 'error calculations' or 'error propagation', hence we do focus on the knowledge calculations, described by DIMF [22, 23] and UDCC [24] for The Conceptual Knowledge Reference Implementation (CKRI) [7], implementations and realisations, including procedural components, computation, and efficient parallelisation [23, 25, 26],

The Component Reference Implementations (CRI) framework [27], and The Universal Decimal Classification (UDC) [28], used for demonstration. The principle methodological insight is independent of the realised classification, however it may impact the creation of concordances between realisations. The practical application in industry, with High Performance Computing (HPC) and Artificial 'Instruments', was addressed by [29]. The methodology and reference implementations can be used in manyfold ways to do decision processes, knowledge analysis, and create knowledge based measures for new methods.

In simplistic terms, the research in this case requires spatial data, objects measurements, classification data and so on. Besides all chorological properties (simplistic: 'spatial'), e.g., longitude, latitude, topometric and bathymetric values, the focus of knowledge processing requires further assignments to all the entities (simplistic: 'atoms') involved. Any entity of a point of interest in space and time, e.g., a prehistoric object entity is assigned conceptual facets (simplistic: 'classification'). Any entity of satellite data, e.g., a hypsometric value is assigned conceptual facets (simplistic: 'classification'). Any entity of a vector objects, e.g., a polygon is assigned conceptual facets (simplistic: 'classification'). Any entity of a processing workflow, e.g., an algorithm is assigned conceptual facets (simplistic: 'classification'). After required numerical processing, in order to achieve a complex task, facets of entities should still be preserved, now being uniquely referenced by the geospatial coordinates with the result of the numerical processing. In simplistic terms, the applied algorithms 'carry' the conceptual knowledge assignments of all involved entities through their calculations, up to the results. And, yes, the general rule is, when employing a method or algorithm, the researcher himself or herself has to take care not to loose the conceptual knowledge during the process and adapt his or her respective implementations and realisations properly in order to achieve that.

In the current research, such work has been conducted with deployment of CRI components, especially the Generic Mapping Tools (GMT) modules and wrapping workflows [15]. Anyhow, details on modifications to certain implementations are out of scope of this research here.

1.1.3 Sub-proem: Numerical Analysis' and Computational Mathematics' Knowledge Integration

Table 1 presents a major subset of CKRI facets on how to methodologically and systematically address numerical analysis and computational with advanced knowledge analysis. Non publicly licensed entity branches (ellipses) can be considered respectively.

Numerical calculations and knowledge analysis can deploy the decimal structure of the conceptual entities and facets of the CKRI and its operations. In addition, multi-lingual verbal descriptions can be used, e.g., with language processing and analysis but also for weighting within complex processes. For demonstration of the principles, unique sources [22, 23] (PAKA) have been used, providing multi-disciplinary coherent conceptual knowledge. This may not be the case for arbitrary sources, which may be considered by researchers not conducting their own measurements for objects. Satellite data with its hybrid structures is not required and therefore not shown in the examples. However, satellite data can be used for hypsometric calibration ob object entities. In such cases, an error calculation may be conducted for scenarios requiring the identification of individual objects.

Contrary to the knowledge analysis, dichotomies of the spatial data can therefore be considered not relevant. The relevant dichotomies are those resulting from the conceptual attribution. In this respect, we do not call the margins 'error margins' but 'conceptual knowledge fuzziness'. The fuzziness of the conceptual attributions of object entities is the result specified by the given facets. The fuzziness of knowledge is not expressed by numerical values at that stage as it is the intended result. The algebraic logic itself, employed for the part of spatial calculation, is not aware of non-algebraic logic. However, errors may be calculated for spatial material and fuzziness given for knowledge entities, separately.

Table 1: Addressing numerical analysis and computational mathematics with advanced knowledge analysis: Implemented CKRI code references of natural sciences, mathematics, environment, and geodesy (excerpt) for multi-disciplinary coherent contextualisation.

Code / Sign Ref.	*Verbal Description (en)*
CKRI: UDC:500	Natural sciences
CKRI: UDC:51	Mathematics
CKRI: UDC:519.2	Probability. Mathematical statistics
CKRI: UDC:519.6	Computational mathematics. Numerical analysis
CKRI: UDC:52	Astronomy. Astrophysics. Space research. Geodesy
CKRI: UDC:528	Geodesy. Surveying. Photogrammetry. Remote sensing. Cartography
CKRI: UDC:528.2	Figure of the Earth. Earth measurement. Mathematical geodesy. Physical geodesy. Astronomical geodesy
CKRI: UDC:528.2...	Fundamentals derived from potential theory. Level surfaces. Geoids
CKRI: UDC:528.2...	Geometric (static) methods. Use of longitudinal and latitudinal measurements
CKRI: UDC:528.2...	Gravity measurement
CKRI: UDC:528.2...	Astro-geodetic determination of position. Geographical coordinates
CKRI: UDC:528.3	Geodetic surveying
CKRI: UDC:528.4	Field surveying. Land surveying. Cadastral survey. Topography. Engineering survey. Special fields of surveying
CKRI: UDC:528.4...	Topographic surveying
CKRI: UDC:528.5	Geodetic instruments and equipment
CKRI: UDC:528.7	Photogrammetry: aerial, terrestrial
CKRI: UDC:528.7...	Photogrammetric aerial triangulation. Determination of control points and pass points
CKRI: UDC:528.7...	Applications of photogrammetry
CKRI: UDC:528.8	Remote sensing
CKRI: UDC:528.8...	Fundamental and physical principles
CKRI: UDC:528.8...	Data processing
CKRI: UDC:528.9	Cartography. Mapping (textual documents)

1.2 Proem: Epistemological Completeness Target

This research and respective rights refer to the gamut of implementations and realisations of knowledge complements, especially including the created expression of contents, structure, and form. For this publication, options for Journal of Numerical Analysis, Industrial and Applied Mathematics (JNAIAM) and Springer Proceedings in Mathematics & Statistics (SPMS) were finally and equivalently available. To this respect, publisher and publishing practice (JNAIAM) were chosen over existing options to respect these requirements retaining consistency, coherency, validity, facts, author rights & interests, and peer decisions, ensuring to preserve all parts of content, structure, and form, including copyrights and formatting of publication, ensuring against modification and disruption by third parties. Information science is the science of information in theory and practice. Essential fundaments of information science are information and philosophy, and require a solid classical education. In this context, in science, preservation and conservation of as much as possible of the completeness of knowledge complements and form are relevant.

2 New Methods, Results, Insights, Achievements

The entirety of group objects, entities, and respective conceptual knowledge references' excerpts and qualities are delivered by Knowledge Resources (KR) of The Prehistory and Archaeology Knowledge Archive (PAKA) [30], released by DIMF [22]. Recent research has been conducted in site surveys, large scale surveys, and campaign context scenarios regarding new insight from prehistoric and classical archaeology. The practical methodological approach addresses knowledge complements and employs the latest versions of The Conceptual Knowledge Reference Implementation (CKRI) [7], and deploys the georeferencing and hypsometry of object entities.

Implementations and realisations, including procedural components, computation, and efficient parallelisation [23, 25, 26] employ The Component Reference Implementations (CRI) framework [27]. Their cornucopia of capabilities enables to sustainably address knowledge complements, especially F actual, C onceptual, P rocedural, M etacognitive, and S tructural (FCPMS), including C and P approaches to symbolic challenges, discovery, and creation of new insight.

2.1 Resulting Methodological Coherent Conceptual Complement Set and Scope Analysis

Table 2 shows the excerpt set of resulting Conceptual Knowledge Reference Implementation (CKRI) conceptual knowledge reference facets, relevant for the new domain-spanning research cases. Here, for demonstration, references are using references based on Universal Decimal Classification (UDC) [28] released (sic erat scriptum, [sic]) by the Universal Decimal Classification Consortium (UDCC) [24, 31].

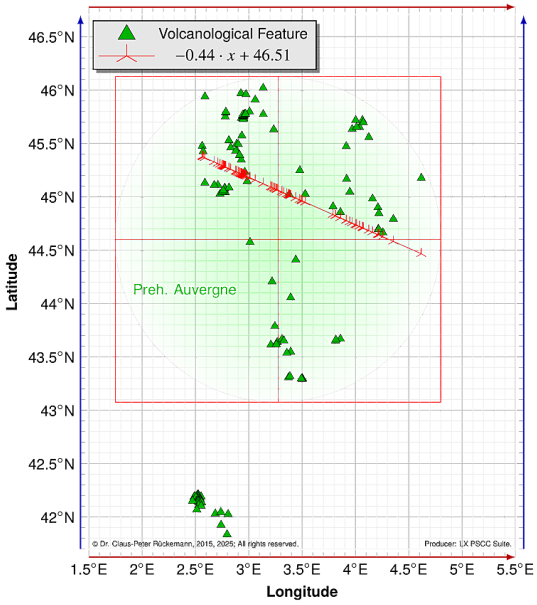
Table 2: New result CKRI: Earth sciences, natural sciences, archaeology, prehistory, and auxiliaries; as given [sic]; (excerpt). The table gives CKRI code based on UDC references, English verbal descriptions, and discovery bifurcation assignments.

Code / Sign Ref.	*Verbal Description (en)*	*Discovery Bifurcation Assignment*
CKRI: UDC:55	Earth Sciences. Geological sciences	α
CKRI: UDC:550.3	Geophysics	α
CKRI: UDC:551.21	Vulcanicity. Vulcanism. Volcanoes. Eruptive phenomena. Eruptions	α
CKRI: UDC:692	Structural parts and elements of buildings	β
CKRI: UDC:711	Principles and practice of physical planning. Regional, town and country planning	β
CKRI: UDC:902	Archaeology	β
CKRI: UDC:903	Prehistory. Prehistoric remains, artefacts, antiquities	β
CKRI: UDC:(23)	Above sea level. Surface relief. Above ground generally. Mountains	β

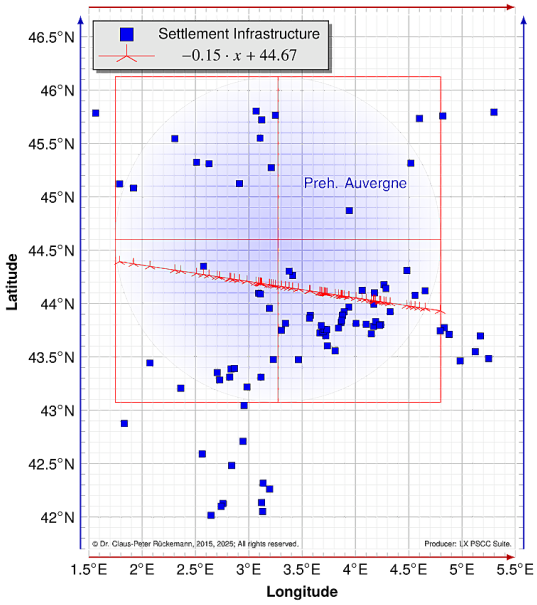
The table lists the discovery bifurcation assignment for knowledge discovery processes of the multi-disciplinary coherent conceptual knowledge facets used with this research. Within the surveys conducted during the last decades, several thousand prehistoric and protohistoric groups of objects and measurements have been targeted by advanced, seamless multi-disciplinary scientific research, hard criteria, and fact-based coherent conceptual contextualisation and analysis. Figure 1 shows an independent graphical representation of the new research results, symbolic representations (Cartesian), georeferencing, hypsometry, and plain linear regression (in specified squares) of the scope analysis for major survey targets, prehistoric and protohistoric object group entities,

- CKRI: UDC:711..,692,903,902 and
- CKRI: UDC:551.21,550.3,(23),

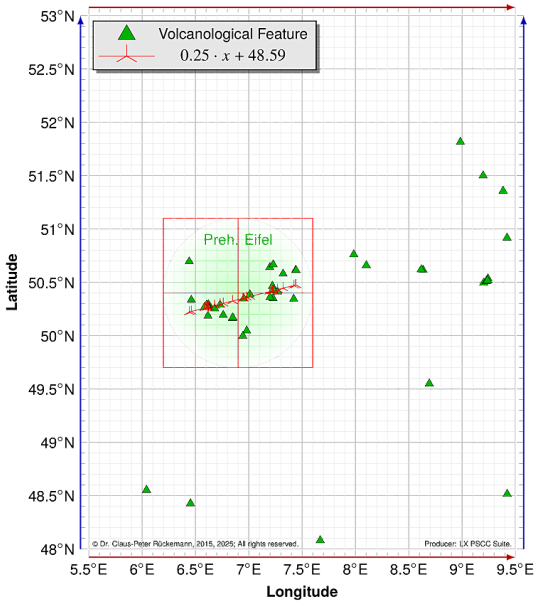
resulting agglomerations of prehistoric / protohistoric Auvergne (FR) (Figures 1(a), 1(a)) and prehistoric / protohistoric Eifel (DE) (Figures 1(c), 1(d)), based on KR objects and multi-disciplinary research, general multi-disciplinary large and compact scale contextualisations and AoI / PoI (Area / Point of Interest) contexts and results from respective CKRI references.



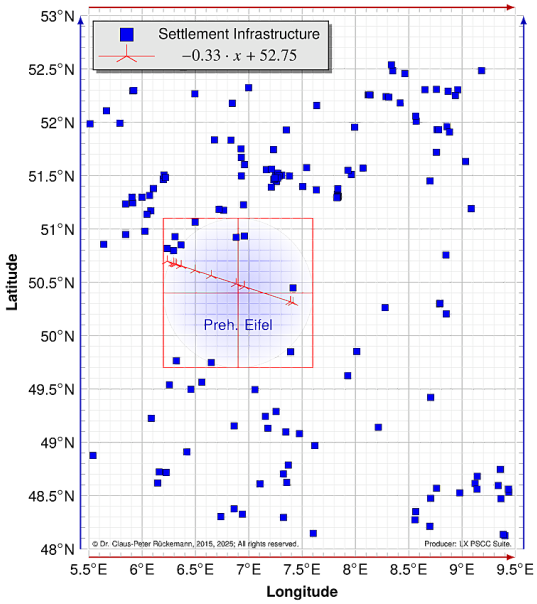
(a) Chorological-conceptual scope of prehistoric volcanological feature object entities CKRI: UDC:551.21... (α) for Auvergne (FR) (excerpt).



(b) Chorological-conceptual scope of prehistoric settlement infrastructure object entities CKRI: UDC:711.... (β) for Auvergne (FR) (excerpt).



(c) Chorological-conceptual scope of prehistoric volcanological feature object entities CKRI: UDC:551.21... (α) for Eifel (DE) (excerpt).



(d) Chorological-conceptual scope of prehistoric settlement infrastructure object entities CKRI: UDC:711.... (β) for Eifel (DE) (excerpt).

Figure 1: New results from chorological-conceptual knowledge scope analysis of prehistoric and protohistoric object entity agglomerations (CKRI facets) in respective AoI (KR objects) (excerpts), symbolic representations, and plain linear regressions, from analysis of surveys and measurements for prehistoric / protohistoric settlement infrastructure objects (blue color square symbols) and volcanological feature objects (green color triangle symbols).

Identified settlement infrastructures (blue color square symbols) and identified volcanological feature objects (green color triangle symbols) and their resulting object agglomerations reveal significant dichotomies. Research was conducted starting 1987–2025 at the Unabhängiges Deutsches Institut für Multi-disziplinäre Forschung (DIMF).

2.2 This Year's Best Practice 'Golden Spike' Result: Multi-disciplinary Coherency

Scientific contextualisation is required for many research scenarios, especially if advanced methodological approaches are required in order to address multi-disciplinary knowledge. The significance of consistent contextualisation is even higher for multi-disciplinary research, especially for disciplines and research targets where multi-disciplinary approaches are most desirable, e.g., for scientific research scenarios of prehistoric and protohistoric archaeology and resulting fact-based contextualisation and analysis. This is also inherent with fact-based approaches to multi-disciplinary contexts and methods, e.g., perception of intelligence and technology [32, 33] and best practice of contextualising radiocarbon dating [34, 35]. Multi-disciplinary coherent conceptual contextualisation is a special methodological approach and sometimes favorable over the general coherent multi-disciplinary conceptual knowledge contextualisation (ICNAAM SACINAS Delegates' Summit 2015–2024 [9], and 2025 [36, 37]). The new methodology coherently integrates all facets of knowledge, realia and abstract objects, e.g., semiotics and symbolic representations (International Information Science ERR OR ART? Campaign (DIMF, 2025), C.-P. Rückemann, samples to be published, 2025/2026). The limiting aspects, esp. of implementations and realisation of artificial instruments, should further always be considered, e.g., regarding formalisation and its inherent processes of abstraction and reduction, e.g., language and numbers [38, 39], as well as regarding natural, inherent, and required complexity, logic, and models.

3 Conclusions, Insights, and Future Research

This research paper presented a new general methodology for coherent and consistent conceptual integration of knowledge complements. The methodology enables an integration of knowledge object entities with numerical mathematics, in theory and practice, e.g., with the contextualisation and analysis employing spatial and hypsometric methods and algorithms, in n-dimensional knowledge space. Multi-disciplinary coherent scope analysis and contextualisation based on CKRI and CRI frameworks proved sustainable, efficient, and effective methodological fundaments for implementations and realisations. Historico-cultural results from archaeological site surveys and campaigns revealed new insights on object agglomerations and correlations, esp. settlement infrastructures and volcanological features, especially central $(\alpha : \beta)$-dichotomies in Auvergne and Eifel regions. The multi-disciplinary context research is contributing to the ongoing fact-based analysis of prehistoric scenarios and their further prehistorical and archaeological contextualisations. Hundreds of scientific on-site research surveys and campaigns have been conducted within the last decades, participating many disciplines and domains, creating multi-disciplinary knowledge resources, and many reference implementations and frameworks [5, 4, 3, 29]. The new methodology and demonstrated knowledge analysis also extend the fields of numerical and applied mathematics by a wide range of new application fields, e.g., contextualisation, knowledge analysis, knowledge discovery, and artificial 'instruments', and opens its epistemological significance an integration into multi-disciplinary coherent information science fundaments and practical employment.

Respective knowledge research requires solid classical education and meritocratic principles for long-term sustainability. The laws of nature and scientific logic state that, besides of phenomena of 'Akasha' and quantum physics, entanglement, superluminal phenomena [40, 41, 42, 43] (VERB. SAP.), which we employ for insight and research since times immemorial, there is and will be no

true Nuremberg Funnel, not Artificial 'Intelligence' (AI) and no other such instruments and tools. "To err is human, to deterministically fail is artificial." (CPR 2025-08-19) [36]. In simplistic terms, scientists should start finding multi-disciplinary solutions and answers to scientific questions from knowledge-based methodologies, not from relying on procedural implementations only.

Future research funded by this long-term project will address multi-disciplinary prehistorical, archaeological field surveys and research on object groups and scenarios, employ these results in new multi-dimensional models and methods, enabling multi-disciplinary coherent contextualisation, survey planning and practical deployment. The new methodology and its systematical employment enable to deliver new insights from advanced, sustainable, and efficient contextualisation and advanced knowledge analysis.

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