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RESEARCH ARTICLE

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The geolocation of features on information surfaces and the use of the open and FAIR data principles in the mountain landscape domain and geoheritage

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Abstract

This note suggests that decimal latitude/longitude [dLL] locations should be used to identify features of interest, landforms, sample and investigations sites, in an 'information landscape' provided by the geomorphological literature. All the information associated with a labelled, or tagged, geolocation should be available for examination as part of information landscapes that can be explored and represented in books, papers and other publications. This note also outlines the 'open' and FAIR data that are findable, accessible, interoperable and reusable and how the principles can be used to better explain landscapes, especially in the mountain landscape domain. Tors and rock glaciers illustrate [dLL] geolocation to identify sites and inform fieldwork and literature searching. Any [dLL]-specified location is an identifying label, as are names given to landforms and toponyms. Two letters (digraph) are used as landform labels: **TO** for tors and **RG** for rock glaciers. Citations, (author–date–title–source) attributions, are also labels. The note shows how these attributions can be linked to [dLL] geolocations specifying locations in time and space and in the literature. The addition of [dLL] will facilitate future literature searches and modelling to explore 'unknowns' in the landscape, and this paper suggests ways in which this can be achieved, including geoheritage and geotourism.

KEYWORDS
decimal latitude/longitude, FAIR principles, geolocation, information surfaces, rock glacier, tor

1 | INTRODUCTION

This note concerns communicating geomorphological information, specifically that associated with sites and locations in landscapes in the domain of mountain landscapes. Geolocation, using a compact decimal latitude/longitude [dLL] format, described below, can easily be attributed to fieldwork locations and embedded in communications. This format allows better spread and use of geomorphic information.[1] The paper also identifies some basic notions about the nature of geological and geomorphological data, site identification and model building and the principles of 'open data'. Geolocation identification helps information/data become more 'open' and accessible. The use of [dLL], when associated with information, also allows discussion about geomorphic problems at local and worldwide scales. This paper also discusses *prior information* and the utilisation of geomorphosites,[2] ways of 'building confidence in geological models'[3] and the significance of open discussion about sites and concepts. The designation of a landscape by a two-letter (digraph) convention helps provide better discussion and cataloguing of geomorphic features. Examples in the mountain domain such as tors, rock glaciers, blockfields and stone streams are used as examples of exchanging geomorphic information.

2 | FIELDWORK AND GEOMORPHIC INFORMATION AS HISTORICAL LEGACIES

It might be suggested that the initiation of periglacial studies was the field trip to Svalbard after the 1910 International Geological Congress in Stockholm[4] where Walery Władysław Daniel Łoziński (1850–1944) introduced the terms 'periglaciation' and 'periglacial zone'. French also notes the significance of Johan Gunnar Andersson (1874–1960) who influenced Łoziński's views after Andersson's visits to the Falkland Islands and Bjørnøya and who coined the term 'solifluction'. Such scientific field trips were, if not common, important in the dissemination of ideas, especially related to field observations. Discussion about 'the glacial theory' was still a significant debating point in the British Isles in the middle of the 19th century. Worsley[5] reports on the 1865 expedition to Arctic Norway of three junior officers of the Geological Survey of Great Britain. These three were Archibald and James Geikie (1835–1924 and 1839–1915) and William Whitaker (1836–1925), and their remit was to gain 'actualistic field experience' of the land-ice versus marine iceberg hypotheses of glaciation. They followed James D. Forbes' (1809–1868) and Leopold von Buch's (1774–1853) earlier visits to the Lyngen Alps and Øksfjordjøkelen area of north Norway.[6] These visits stem from scientific curiosity, exploration–discovery and the need to formalise problems (such as rival glacial theories) and to identify, or speculate on, deposits, features and processes. We might call this, in earth science terms, 'investigative fieldwork'. Fieldwork, and associated subsequent office and laboratory investigations, provides the basis for earth science knowledge and the building of explanatory models. The discovery of the Siccar Point (Hutton) unconformity and the nature of the Moine thrust by Peach and Horne at Knockan Crag are classic examples of geosites from Scotland that changed prevailing views. (It was Archibald Geikie, then Director of the Geological Survey, who sent Ben Peach and John Horne to do detailed mapping of the Moine schists in 1883, 'the Highlands Controversy'.) Investigative fieldwork leads to discussion, with or without publication; 'here is the evidence of …', which is also true of 'demonstrative fieldwork', as usually carried out with students but may be with professional colleagues or interest groups. The geologists in Norway just mentioned are early instigators of 'geotourism', nowadays followed by cruise ships. Hose[7] has suggested that geotourism incorporates inter-relationships between geo-interpretation, geoconservation, geohistory, geosites and geomorphosites,[2] and geodiversity as well as archives, museums and art galleries. Unusually for geology in the British Isles, Knockan Crag on the Moine Thrust has its own visitor centre (and Wikipedia page), but most geosites are reported in 'the literature' (including books, reports and theses), and investigations are usually identified, sometimes ambiguously, by place names (toponyms).[1] Each investigative observation or measurement we make depends on some assumptions about the existing data and information: a *prior model*, as a mental model. We can say how, when and where observations and data were acquired and are reported as previous. This paper is concerned with reporting fieldwork results and locations as prior information.

3 | INFORMATION OVERLOAD AND UNCERTAINTY

Fieldwork in earth sciences has followed the pattern mentioned above: reporting results from case studies in ever-increasing numbers of outlets. Such studies can be identified by searches, typically using *Google Scholar*, and are recorded, as in bibliographies, with (author, date, title, source) (adts) labels representing information contained within the paper.

Geomorphology essentially collects data about individual landforms, and each landform needs to be identified and catalogued with respect to the 'information' about each case study. If site investigations were to be reported according to precise locations, then it should become easier to answer the basic question posed by Murton[8]: 'What and where are periglacial landscapes?' Murton notes that the 'uncertainties about landscape evolution under cold, nonglacial conditions raise [this] question fundamental to periglacial geomorphology'. As recognised by Bowden,[3] 'uncertainty' can be defined as 'anything we are not sure of', and Bowden lists several ways in which we can be 'unsure': incomplete knowledge of the process, the system, quality of data, meaning of terms and data variability. Bowden also notes the significance of 'conflict': when we have data from different sources, but where conclusions from the data do not agree. Scientific conflicts were undoubtedly debated by early geotourists, and subsequently in journals, at meetings and in bars. The terraces of (glacial) Lake Missoula were noted as possible lake levels by T. C. Chamberlain of 'multiple working hypotheses' fame and an exponent of climate changes resulting from atmospheric carbon dioxide concentrations.[9] Chamberlain had read about the 'Parallel Roads of Glen Roy' in Scotland in 1896, and Lake Missoula was later interpreted by J. Harlen Bretz as the source of water for an outburst flood that produced the 'Channelled Scablands' of southeast Washington state.[10] This transfer of ideas was curtailed because such 'notions' of catastrophism were not believed at the time, the 1920s. A 'geotourist' approach to the evidence and explanation is provided by Waltham,[11] who notes that accrual of new data eventually justified Bretz's ideas. As Waltham[11] reminds us, 'then in 1962, a field trip from the Quaternary Research Congress took many senior participants to the scablands. Bretz was too ill to attend, but at the end they sent him a telegram to say he was right'. Dogmatic views need discussion provided by open data, a philosophical viewpoint that dogmatism is ultimately untenable.[12] A more recent field conference in the Columbia Basin and further of Bretz's 'outrageous hypothesis' is given in Baker and Nummedal.[13]

To promote discussion about landforms and possibly reduce uncertainty in interpretation, I now look at two features of the periglacial domain, tors and rock glaciers, included in the recently published volume on periglacial landforms in Europe.[14] Availability and the identification of geosites and their related information can be explored by the FAIR data principles and a means of geolocation designation to identify and record sites in the literature.

4 | OPEN DATA AND THE *FAIR* PRINCIPLES

Open data are openly accessible, exploitable and editable and can be shared by anyone for any purpose. The Open Knowledge Foundation[15] indicates that data should accord with the following:

- *Availability and access:* Data must be available as a whole and at no more than a reasonable reproduction cost and be available in a convenient and modifiable form.
- *Re-use and redistribution:* Data must be provided under terms that permit re-use and redistribution including the intermixing with other data sets.
- *Universal participation:* Everyone must be able to use, re-use and redistribute—there should be no discrimination against fields of endeavour or against persons or groups. For example, ‘non-commercial’ restrictions that would prevent ‘commercial’ use or restrictions of use for certain purposes (e.g., only in education) are not allowed.
- These stipulations (which will not be discussed further) relate directly to the FAIR data principles[16(p.1)] that involve findability, accessibility, interoperability and re-usability of data, that is, promote the use of open data. The FAIR principles may be stated in outline: ‘Good data management is not a goal in itself, but rather is the key conduit leading to knowledge discovery and innovation, and to subsequent data and knowledge integration and reuse by the community after the data publication process’.[16(p.1)] Interoperability is significant: the ability of diverse systems and organisations to work together with the ability to interoperate between data sets.

The present paper shows how the FAIR principles relate to some periglacial, that is, mountain domain, land systems and the information referring to them. In particular, locational specifications, via decimal geolocation [dLL], and information about features are important in knowledge transfers that promote scientific advances. The methodology outlined here will make searching for landform references in the literature easier, and open discussion will reduce uncertainties in meaning and interpretation.

5 | [dLL] GEOLOCATION SPECIFICATION

Various map-based, grid projection systems are traditionally used to help specify locations often used in reports and field guides. As an example, the hill known as Great Cockup in the hills of the English Lakeland is NY273333 in the British National Grid system. This geolocation system is not interoperable internationally (and Great Britain has a different system to that on the Island of Ireland). The hill has information associated with the name and location (Wikipedia entry: https://en.wikipedia.org/wiki/Great_Cockup). It can be identified by using the degree, minute, second (dms) designation, but this is unwieldy and can be rendered in different ways typographically. More convenient is a [dLL] specification as a two-element ordered pair, or tuple: [54.68966,−3.12874]. The convention is latitude and then longitude as decimal degrees to an appropriate number of decimal places and that a keyboard hyphen/minus (Unicode U+002D) specifies the southern hemisphere for latitude and west of the prime longitude. This value identifies the location when copied directly into Google Earth and can also be pasted into the Ordnance Survey's digital online maps. This format has been used in a geomorphological context[1,17] to locate a feature, photograph location, data sampling point in a database, catalogue or inventory. Using [dLL] helps interoperability and avoids possible confusion by using place name (toponym) labels alone. For example, a landform may have a variety of associated features that can be discussed, shown to be similar, or dissimilar, features elsewhere or have different names in the literature; examples are given below. Using a [dLL] minimises ambiguity and itself also becomean information source between associated observations. The following sections use this [dLL] convention to help locate and explain features as part of open data as part of ‘information landscapes’.

A [dLL] is a succinct label for a place and can be searched for and placed in a GIS or database. Moreover, a [dLL] can be used as an identifier for other information that might be associated with it, such as a date or sample. Thus, The Robin Hood Inn [53.2456,−1.5820] specifies a public house (‘pub’) near Sheffield, South Yorkshire, not one of eight others of the same name in the Pennine area, or Sheffield, Cornwall. There are nine Sheffields in the United States as well as Australia and New Zealand. Geolocations can be associated with the information contained within publications, the name of which will have its own label such as ‘Pub Walks in the Pennines’ with the author citation[18] also being a label. As information is becoming increasingly digital, searching for appropriate labels should be facilitated by digital methodologies.

Identification of a landform, field site or pub, allows it to be visited in person or ‘virtually’, via open tools like Google Earth (GE) or OpenStreetMap (OSM). Thus, Greatcockup [54.68966,−3.12874] can be referenced in a field guide; [dLL] makes for interoperability. Data also become more accessible and open, and perhaps become part of a geomorphosite visit, either in person or by virtual (drone-enhanced) geotourism and conservation.[19]

Machine learning (ML) techniques and new methods of visualisation now offer improved searching and analysis.[1] The following sections outline the importance of these ideas and how they can be put into practice.

6 | USING [dLL] AND THE GEOMORPHOLOGICAL LITERATURE

The FAIR requirements apply to previous as well as new investigations. The case studies collected in *Periglacial Landscapes of Europe*[14] ('PLoE') are (adts) indicative labels but are not full open data, being behind a paywall. Note that 'PLoE' is a label, although not as well specified as its ISBN 978-3-031-14894-1 or doi.org/10.10007/979-3-031-14895-8. As with PLoE, geosites mentioned in papers or guides are only loosely defined toponyms with (adts) citations with poor geolocation. Physical and electronic textbooks are 'information bundles', where bundles are 'organized, highly selective collections of information to help solve problems and maintain situational awareness'.[20(p.1248)] However, as PLoE has no index of landforms or locations, researchers must manually sift through the accumulated knowledge of books and papers. A book, especially a textbook, is often a 'messy bundle', a mixture of findings, ideas, images, author citations and sources that provide a space for analysis or scrutiny of specific landforms but tend not to be 'open', especially for discussion. Nevertheless, PLoE is a useful compendium of various labels, rather than a catalogue of field sites, that help identify landforms in the mountain (aka 'periglacial') domain of Europe, although chapters and papers must be perused individually. This is not a digital process even in the e-book version. Some landforms can be placed within debris transport systems ('processes') showing landscape development, but the information resides inside (adts) referencing. The examples used below, tors and rock glaciers, are part of the ensemble of features that can help identify the 'where and what' of periglacial landscapes.[8] The data/information in the literature, such as in PLoE, provides *prior information* for future model building, examination and testing, but geolocated landform data are required for this.

7 | FEATURE IDENTIFICATION AND LOCATION AS PRIOR INFORMATION FOR MODEL BUILDING

In the characterisation of landscape domains, landforms are usually taken as a fundamental, visually recognised, entity. However, unlike fundamental particles (e.g., an electron), a recognisable landform (e.g., a tor) has no unique properties of material composition or formative process/mechanism or indeed past or present 'behaviour'. However, [dLL] geolocation can be used to compare landforms with different geologies, aspects or altitudes. This has been used in mapping features[21–23] by ascribing a simple, two-letter or digraph, label to a feature. Thus, **TO** identifies a tor (associated with the labels koppie and castle koppie; Table 2). Tors may, but not exclusively, be in granite.[24,25(p.85–87)] The 'problem of tors' was the title of Linton's[26] paper where most attention was on the Dartmoor tors and their development, especially granite weathering. To investigate sizes, origins, geologies and so forth, the location of a tor that can be associated with existing, that is, prior, investigations is required. For example, **TO** [53.3167,−1.6206] specifies Owler Tor, on Millstone Grit, Upper Carboniferous, Derbyshire England, but this example is not linked to a specific paper. However, it is in the Burbage area [53.3431,−1.6100] as investigated by Said.[27] This site might be compared to **TO** [57.0992,−3.4342], an unnamed, granite, tor on Ben Avon, in the Cairngorms of Scotland. The latter is shown in Gordon and Brazier[28] along with a discussion of tors in the Cairngorms. A generalised, but certainly not complete, reference to papers about tors in Scotland would be the information label set: **TO**{Scotland,(Gordon and Brazier, 2021),(Ballantyne and Murton, 2022)}.[29] This set is denoted as a comma-separated variable string that might be used in an ML search. To the set, specific examples, such as **TO**[57.0992,−3.4342], and detailed papers, such as the 32 tors listed by Gunnell et al.,[30] could be added. In principle, aggregated information, such in a Wikipedia entry, provides a potential database. The book *Landforms of the Earth*[31] lists 'tor' and 'nubbin' under 'Granite landforms', but not under 'periglacial landforms'. Twidale,[32] in a discussion about granite tors, includes a photograph of Hay Tor west [50.5798,−3.7566], which could be searched for in the set {**TO**[50.5798,−3.7566](Twidale, 1982)}. Thus, a simple set's contents can be used to specify site information. The information [50.5802,−3.7552] could be used in future studies to compare tors in the British Isles, for example. Gunnell et al.[30] *do* provide (in their tab. 1) six-decimal degree locations of the DM1–32-labelled tors in their study of tor denudation. However, their images and text references refer only to toponyms and DM labels and so are not intrinsically machine-findable.

The location space of 'the literature' can be used to select appropriate sites and studies for inclusion in new studies, whether in Europe or beyond. Such site inclusions may be referred to as 'previous work …'. For example, Máčka et al.,[33] not included in PLoE, list some tor investigations, but comparisons can be done only by reconfiguring the data because toponyms are mentioned in the text. The review of 'sandstone rocky forms' (as geosites) in the Polish Carpathians[34] for educational and tourism attraction has excellent, although not geolocated, examples but has no reference to 'periglacial' or is mentioned in PLoE.[14]

8 | MESSY BUNDLES AND PRIOR INFORMATION

In future, searching 'messy bundles' (books) for prior information using ML techniques should provide a way of obtaining site data as well as analytical enquiries with multiple search terms (variables) provided a [dLL] is given. This provision would aid findability in workflows and make data more 'open'.[35] A search might help answer questions that are difficult or intractable with traditional methods using bivariate regression techniques. Research questions might be related to the significance of tors under periglacial conditions, pre-glacial tor remnants, geographic location relationship to geological control, exposure dating and emergence rates from surrounding blockfield denudation. However, the search area or 'location space' needs to be wider than 'Europe'. Such questions show the nature of geomorphological problems in answering Murton's, 'what and where are periglacial landscapes?'. Whalley[1] outlines a variety of data mining and analysis techniques that might be used in the future.

The contents of a 'previous work', in a paper or for a research proposal on tors in the landscape, becomes an information data set: *prior information* for new studies. 'Prior information is that which is provided as an *a priori* component of a solution to any problem of interest. That is, it comprises all information that pre-existed to the collection of any new or current data sets that were designed specifically to help solve the problem'.[26(Preface, vii)] The 'priors' might be agglomerated as a set: **TO**{all papers and illustration of the features named 'tors'} as, for example, those in Scotland, southwest England and the Pennines. The tors located at the feature called 'Stiperstones', of which Manstone Rock is the largest **TO** [52.5818,−2.9348], were mentioned by Linton[36] and elsewhere in passing. But we may also want to examine **TO**{landscape modelling}. Clark[37] indicates that the Stiperstones, 'are taken to support the proposition that cryoplanation is a real and significant part of landscape modelling in periglacial conditions'. Clark places these **TO** as part of a land system approach with weathering being a source of material that is then moved downslope. Anderson[38] uses land systems with a modelling approach to tors in the Wind River mountains, Wyoming. 'Many of the features of these high surfaces appear to be attributable to the operation of the Quaternary climate and the periglacial and glacial processes that it drives'. (Anderson does not provide a location for the **TO** on the Goat Flat mentioned and shown but may be at **TO**[43.3003,−109.6144].) Data using [dLL] labels and landform digraph designators (e.g., **TO**[52.5818,−2.9348]) are interoperable via associated prior information in a report. Perhaps future discussion might be related to 'where **TO** are not present', that is, the etchplains (or cryoplanation surfaces) from where the bedrock has been removed with the **TO** as a remnant. In this purview, the sarsens of southern England are 'periglacial'[39] as the result of a field excursion, although they are not mentioned in PLoE. As Waltham[40] has it regarding the gritstone **TO** in the Dark Peak of Derbyshire, 'residuals are normal features of a landscape, just the last bits to be eroded away. … To understand their origins, think not of why they are there, but think of how the surrounding rock was removed'. Such thoughts return us to Julian Murton's[8] abstract 'polygenetic periglacial landscapes, which inherit ancient landsurfaces on which periglacial landforms are superimposed to varying degrees, presently or previously' (p. 186).

9 | GEOMORPHOLOGICAL MODELS AND UNCERTAINTY

Models are required, 'because we do not have complete knowledge, in time or space, of the system of interest. Models are constructed in an attempt to represent the system and its behaviour based on interpretation of observations and measurements (samples) of the system, combined with informed judgement (expert opinion) and, generally, constrained for convenience by the limitations of the modelling medium'.[3(pp.157–158)] The complex inter-relationships in landform systems developing over time with other variables such as geology and climate give uncertainty in our knowledge: 'anything we are not sure of … a function of our belief in in our understanding of a system and its behaviour'.[3(p.158)] Note that 'belief' here is a *communal* response. Individuals may or may not believe in the prior information, although Toulmin's[41] evidence-warrant methodology may help provide a consensus view. Evidence from one site might not always tally with that from another; the 'tor problem', 'what do **TO** really represent?', is one such. New data may disprove an idea or add weight to a different model. We might envisage a worldwide assessment of tors and their properties: **TO**{geology, height extent, disposition to related features and exposure dates etc}. In the British Isles, for example, tors can be found from coasts[42(p.538)] to uplands using the definition, 'plateau or plateau-margin bedrock outcrop that rises above the surrounding ground on all sides as a result of more rapid surface lowering of the surrounding ground'.[42(p.582)]

As well as in situ weathering, tors are also part of landscape-wide, slope-continuum landscape models or generalisations. As such, they can be investigated by modelling approaches of Anderson,[38] the landscape overview of Murton[8] and the map-based approach of Evans et al.[43] to the landscape of Dartmoor. This is a case of providing more data for search tools of the future. Google Scholar uses the label (author–date–title–source) approach, together with title and keyword searching. However, the references produced by Google Scholar, 'search products', still must be examined by eye, and *then* the required paper must be obtained and searched. Any 'related searches' can be produced, but the choice, and thereby information obtained, can still be bewildering. The complexity is seen in the commendable, but un-indexed, compilations in PLoE. Searching for 'New Zealand tor' shows many examples that do not appear in much of the literature. For example, (Stirling, 1991, peneplain) gives (Stirling 1991)[44] and tor-related results. A Google Earth search suggests that a good candidate for Stirling's is **TO**[−45.33455,169.20813], although this was not given in the paper, it shows the potential for search methods of the future using [dLL] labels. The work reported by Stirling[45] is also relevant in terms of the 'what and where' of **TO** and their significance in landscapes. What tors represent may be clear in landform identification but complex in time-process significance and thus need evaluations of evidence. Tors, as a generalisation **TO**, need to be envisioned as a collection of landforms subject to model testing. Locations of tors need to be identified and coupled with the attributes of each. Because intermediate positions may not be known, perhaps the 'sum over histories' (path integral) approach of Feynman might be adapted to elucidate Cenozoic landscape (non-quantum mechanical!) histories. In any case, hypothesis evaluation at field sites will be necessary. Worsley's[46] inspection of the fieldwork undertaken by Charles Darwin at Llanymynech Hill [52.7845,−3.0911] provides an interesting example of fieldwork in Wales following Darwin's instruction by his mentor J.S. Henslow and earlier by Adam Sedgwick. Worsley's site interpretation of possible periglacial features uses the UK National Grid referencing system for location of sites and images, and the [dLL] location just provided for Llanymynech Hill has been translated from this system.

10 | THE PROBLEMS OF ROCK GLACIERS: CONTROVERSY, UNCERTAINTY AND INCLUSION

The identification of a **TO** is not periglacial specific, and ‘tors are considered as good examples of equifinality’.[24] I now show how [dLL] can be used to examine the information available about a specific mountain domain landform, rock glaciers, denoted here by the label **RG**. This is more than a problem of defining ‘what is a rock glacier’ or even ‘is that a relict rock glacier’[47] or the differences between ‘fossil’, ‘relict’ and ‘transitional’ **RG** types. Diagnostic features often need specific locational references, although it is rare for landforms to have ‘type sites’. Some papers may not include all the relevant, place-related, data. Making data available using [dLL] labels together with landform and citation labels can open up debate. Bierman and Montgomery's[48(p.321)] textbook summarises some of the issues:

> Rock glacier genesis is controversial with some arguing that interstitial ice forms in place from percolation of surface water and others suggesting that rock glaciers are simply debris-covered glaciers with ice …. It is important to realize that while RG are a distinct landform, there may me more than one way in which they form (the problem of equifinality, in which the landform is not diagnostic of the processes by which it is formed).

Simply stated, there are three main models of how rock glaciers take up their present topographic forms[49] (Table 2):

> ‘permafrost’—ice–rock mixture or ‘cryogenic’ (i.e. they are ‘zonal’ usually called ‘periglacial’).
> ‘glacigenic’—glacier core under debris (i.e. azonal, can occur ‘anywhere’).
> ‘catastrophic landslide’ collapse with flow-like features (azonal).

Evaluation of these models is not discussed here. Rather, attention is given to data availability, interrogation and the recording of prior information and the linking with this to site examples. With respect to the third model, references to possible fossil rock glaciers (**RGf**) in quartzite that have been re-interpreted as rock slope failures (**RS**) in Donegal, Ireland,[50–52] and on Jura, Scotland.[53] These references are presented with toponyms, and [dLL] citations in a separate list format, [L1]–[L11], with author citations, are collated as Table 1.

The compilation PLoE[14] provides many examples of **RG**. However, these are incomplete, either because investigations were published and accessible only after the PLoE compilation or for some reason were not included. The overview of an area in north Norway, Lyngen [69.576,20.215] provided by Leigh et al,[58] is not included in PLoE. However, Leigh et al[58] *do* discuss rock glaciers, some of which had been reported earlier (Griffey and Whalley 1979 [L6]; Whalley 1976 [L7]; Whalley 1992 [L8]) but are not included in PLoE. Leigh et al's[58] map links features to the Norwegian glacier inventory position, but the glaciers are themselves not georeferenced. The [dLL] list in the present paper gives geolocations for these Lyngen rock glaciers for the first time. Open data encourages inclusivity in referencing site information by statements about locations and published prior information.

11 | FEATURE IDENTIFICATION AND MAPPING ROCK GLACIERS WITH [DLL]

I now show how data/information can be made more identifiable and sharable in the literature generally using [dLL] for both named features (usually landforms) and data sampling. As indicated with **TO**, locations of interest together with the references in the literature can be brought together using [dLL]. A wide range of features, locations and their inter-relationships can be explored. As shown in Whalley[21–23] and Table 2 using digraph labels (such as **RG** for rock glacier and **TO** for tor) for landforms can be used in geomorphological mapping and landsystem transfers of debris and materials downslope. Labels can be used to identify specific features. Transects, for example, showing geophysical or UAV profiles, might be shown on images but rarely are the locational data included that would aid between-site interpretation such as transitional types or relict features.

Present procedures using local names and labels *within* papers are obviously useful (as with the lists of tors, DM1–32 above) but should be supplemented by appropriate geolocations. Not only does this help readers but in future will be of help in making comparisons between sites to aid findability and accessibility. For example, the data points of Thibert and Bodin[59] on **RG**,Laurichard[45.0187,6.3999] could be identified to centimetric precision if necessary for a re-survey (perhaps by UAV). Rarely do site photographs include dLL locations that would aid Interoperability between terms, languages and disciplines. As geomorphology has no rigorous classification scheme, papers are usually individual case study interpretations and past studies, if geolocated, also help re-usability. All these principles combine in the provision of good data management so that data analysis enhances the knowledge base. Case-based reasoning can provide a problem-solving paradigm for *geomorphological knowledge modelling*.[60] We now turn to the traditional aspect of geomorphic information, author citations in ‘the literature’.

12 | DATA AVAILABILITY, INTEGRATION AND INTERPRETATION

Several recent papers provide a ‘growing interest of the scientific community in mountain permafrost’.[61(p.2)] This interest is seen in six recent articles involving rock glaciers in this journal: **RG**[64.5001,−51.2666] Abermann and Langley (2022)[62]; **RG**[46.8946,10.7527] Fleischer et al. (2022)[61]; **RG**[46.4976,9.9227], **RG**[46.4296,9.8209], **RG** [46.1765,7.8449] Pruessner, Huss et al. (2022)[69]; **RG**[45.0187,6.3999] Thibert and Bodin (2022)[59]; **RG**[−31.8846,−70.2509] Villarroel, Ortiz et al. (2022)[68] and **RG**[46.0105,7.2449] Wee and Delaloye (2022).[63]

TABLE 1 Locations listed in the text with geolocations and author citations.

L1	[55.9008,−6.0002]	Dawson[53]	Beinn an Oir, Jura, Scotland
L2	[55.8798,−6.0241]	Dawson,[53] Dawson and Ballantyne[54]	Beinn Shiantadh, Jura, Scotland
L3	[55.0302,−8.1294], [55.0395,−8.1058]	Wilson[50]	Errigal I, Errigal IV, Donegal, Ireland
L4	[55.0617, −8.0857], [55.0652, −8.0783]	Wilson[51]	Aghla Mor I, II, Donegal, Ireland
L5	[55.0936,−8.0121]	Wilson[52]	Muckish, Donegal, Ireland
L6	[69.7677,20.0727]	Griffey and Whalley[55]	Veidalen, N Lyngen, Norway
L7	[69.7034,20.2109]	Whalley[56]	S. Strupbreen, N Lyngen, Norway
L8	[69.3752,19.7692]	Whalley[57]	Ellendalen, S Lyngen, Norway
L9	[44.6190,−109.7477]	Meng et al.[79]	Sulphur Creek, Wyoming, USA
L10	[61.3849,−142.7452]	Meng et al.[79]	Sourdough, Alaska, USA
L11	[37.9919,−107.7864]	Meng et al.[79]	Gilpin Peak, Colorado, USA

Note: **Location listing**: fossil rock glacier [dLL] and author reference interpretations, local place names. Note that, to avoid confusion, four decimal places are used and refer to the snout/front area of the feature.

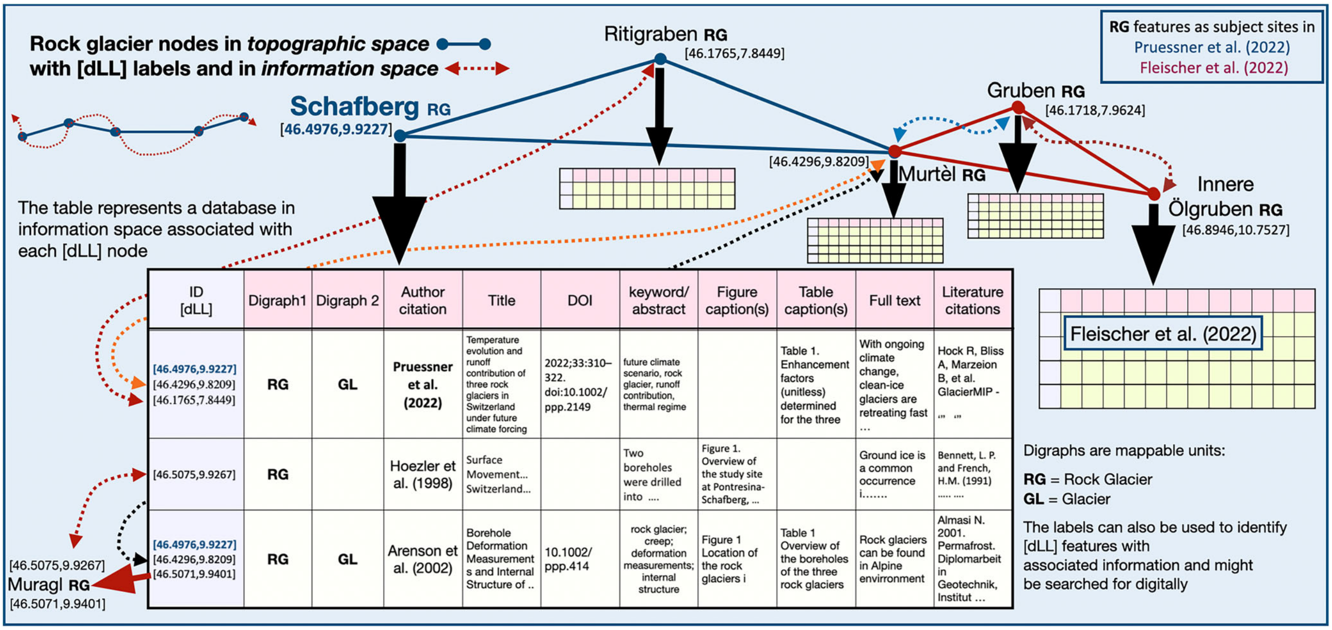
TABLE 2 Geomorphic digraph meanings as used in this paper. A fuller list for mountain domains is given in tab. 1 of Whalley (2021b).

Digraph label	Brief label	Name cognates	Definition by visual inspection With example relevant to this paper (local toponym as appropriate)
AS	Archaeological/ geoheritage site		Usually named **AS**, Stonehenge [51.1788,−1.8261] **AS**, Knockan Crag [58.0335,−5.0710] Also as heritage geosite
BF	Blockfield	Felsenmeer, block field, stone field	Near-horizonal weathered debris, plateau-summit areas, cf. **SR**
BO	Boulder		Large (usually) block or large distinctive stone **BO**, Toadstone [51.43509,−1.80811] Might be part of larger structure, e.g., **BO**, Avebury [51.42756,−1.85547]
GL	Glacier	Gletscher	Typically easily recognisable, high albedo, distinctive margin
RG	Rock glacier	Blockgletscher	Rock glacier, usually distinctive flow forms and steep snout
SR	Stone run	Stone river, stone stream	cf. **BF**
OC	Outcrop		Usually identifiable in the field **OC**, Llanymynech Hill [52.7845,−3.0911]
TO	Tor	Koppie, nubbin, Felsburg, skani hradba, bornhardt	
BF/SR	Blockfield or stone run	Example of combination where distinctions may be unclear	

Such papers give observations of an 'information landscape' about mountain topographic domains in which **RG** are one component landform. Here, I extend the paper of Fleischer et al[61] about *Innere Ölgruben* rock glacier and other papers involving rock glacier studies more generally. The *Innere Ölgruben rock glacier* can be identified by its name and is given the label *OegRG* by Fleischer et al.[61] Although this label stands in for 'Innere Ölgruben rock glacier' and is convenient in a paper, it has the same topographic location as denoted by the label *RG18*[64] and *RG-01*[65] but is distinct from the *Aussere Ölgruben rock glacier*[66] and the *Gruben rock glacier*[67] RG[46.1718,7.9624].

Figure 1 shows the complexities of linking even a few designations of **RG** with their literature-derived toponyms and [dLL]. Within a searchable digital framework the intersection of topographic surface locating a [dLL] with the information surface (generally, from the literature) this should lead to greater insights of relationships.

Internal labels such as *OegRG* provide a non-unique referencing system where other features and locations may need to be compared to that site. The feature *OegRG* is shown in Fleischer et al[61] on a map and with photographs[61] where the UTM zone system is used. Other recent papers listed above with associated [dLL], may use a variety of



ID [dLL]	Digraph1	Digraph 2	Author citation	Title	DOI	keyword/ abstract	Figure caption(s)	Table caption(s)	Full text	Literature citations
[46.4976,9.9227] [46.4296,9.8209] [46.1765,7.8449]	**RG**	**GL**	**Pruessner et al. (2022)**	Temperature evolution and runoff contribution of three rock glaciers in Switzerland under future climate forcing	2022;33:310–322. doi:10.1002/ ppp.2149	future climate scenario, rock glacier, runoff contribution, thermal regime		Table 1. Enhancement factors (unitless) determined for the three	With ongoing climate change, clean-ice glaciers are retreating fast …	Hock R, Bliss A, Marzeion B, et al. GlacierMIP - “” “”
[46.5075,9.9267]	**RG**		Hoezler et al. (1998)	Surface Movement… Switzerland…		Two boreholes were drilled into ….	Figure 1. Overview of the study site at Pontresina-Schafberg, …		Ground ice is a common occurrence i…….	Bennett, L. P. and French, H.M. (1991) ….. ….
[46.4976,9.9227] [46.4296,9.8209] [46.5071,9.9401]	**RG**	**GL**	Arenson et al. (2002)	Borehole Deformation Measurements and Internal Structure of ..	10.1002/ ppp.414	rock glacier; creep; deformation measurements; internal structure	Figure 1 Location of the rock glaciers i	Table 1 Overview of the boreholes of the three rock glaciers	Rock glaciers can be found in Alpine envirronment	Almasi N. 2001. Permafrost. Diplomarbeit in Geotechnik, Institut …

FIGURE 1 Schematic representation of the information associated with some papers referred to in the text considered as topographic features (digraphs; **RG** rock glacier and **GL**, glacier) and held within a potentially searchable database in 'information space' using [dLL] geolocations. © W.Brian Whalley CC BY-NC 2023. [Colour figure can be viewed at wileyonlinelibrary.com]

georeferencing forms as well as local toponyms that may or may not be used in the paper's title. For example, Villarroel et al[68] use a degree, minute decimal (dms) identification to show the complex, multi-lobe *El Gigante rock glacier*, while Pruessner et al[69] use CH1903+/LV95 coordinate system to identify three study sites. Thibert and Bodin[59] use a decimal degree system with two decimal places; however, this is insufficient to identify the *Laurichard rock glacier*. Using the cited co-ordinates, 45.01°N,6.37°E, Google Earth (GE) locates this 2.5 km west of the actual geolocation [45.0187,6.3999]. This diversity of georeferencing is not helped because the feature located and investigated cannot easily be referred to other example or even other investigations on the same feature. Thus, **RG,**Schafberg[46.4976,9.9227], the first of the features referred to by Pruessner et al,[69] has only a nominal reference to the paper by Kenner et al[70] that contains different information about the feature and no reference to the study of Hoelzle et al.[71] Similarly, **RG,**Ritigraben[46.1765,7.8449] has information in Lugon and Stoffel[72] that is not referred to by Pruessner et al.[69]

The label **RG**[46.8946,10.7527] locates the main snout or front of *OegRG* with no ambiguity. The location **RG**[46.89303,10.754182] identifies another (the label *Front 2* of Fleischer et al[61]). This scheme is used with reference to rock glaciers and historical imagery, including the *OegRG*, in Whalley.[21] An additional term in [46.89600,10.76612, @2016] identify the nearby (lake) *Karsee* and 2016 imagery. Using [dLL] establishes geomorphological features on an information landscape, here related to the neighbourhood of [46.894,10.752]. The data presented by Fleischer et al[61] accept the previous work at *OegRG* by Berger et al,[73] where 'rock glaciers are best defined by their morphology rather than their origin or thermal conditions'. Berger et al[73] also noted that *Karsee*, **LA**[46.89600,10.76612], indicated 'a massive ice body'. The geophysical investigations at *Innere Ölgrube* by Hausmann et al[74] referred to 'ice-rich permafrost' although Berger et al[73] at *Innere Ölgrube* indicate a glacier ice origin for rock glaciers in the neighbourhood, such as *Reichenkar* **RG**[47.0494,11.0328] found in Krainer and Mostler[75] and Krainer et al.[76] New information, in the literature, can be added to past priors using specifications of the landform and its location and the new information appended to that as a data set. Thus, Whalley[1] shows the addition of an extracted ice core from a previously reported rock glacier; **RG,**Galena Creek Rock Glacier[44.642,−109.791] with work done on a Geological Society of America Chapman Conference field trip reported in Gillespie et al[77] with papers in *Geografiska Annaler.*[78] Recent work is reported by Meng et al[79,80] **RG**[44.6508,−109.7907] showing the existence of glacier ice at that location. Meng et al[79] also refer to downloadable supplementary material with its own DOI.[80] This additional material increases the general prior information about that one feature and can be used as information for models used to interpret features, landscapes and domains. This includes related geophysical **RG** investigations at Sulphur Creek, WY [L9], Sourdough, AK [L10], Gilpin Peak, CO [L11].

13 | GEOHERITAGE AND GEOTOURISM

The examples using labels, such as **TO**, representing 'tor/s' in general and **RG**, representing 'rock glacier/s' in general, can provide links between information and specific geolocated sites, [dLL]. A similar configuration to Figure 1 for discussion about **TO** should be enlightening given the diversity of landforms called tors (or their synonyms) as mentioned above. Some tors have become part of geoheritage landscape as with for example, Haytor on Dartmoor **TO,**Haytor [50.5802,−3.7552]. A recent paper by Kim and Ma[81] provides an insight into tors and the formation of 'blockfields' and 'stone runs' and investigates a 'stone run' at **SR,**Mt.Okryon[40.5360,127.7306] in Korea from a geoheritage viewpoint. Stone runs have various other names in the literature and may be related to 'Blockfields' (as in table 1 of Kim and Ma). Introducing generic visual labels: **SR** for stone run (=boulder run, boulders on valley floor along thalweg but ≠blockfield). Similarly, **BF** blockfield (=Felsenmeer, near-horizonal weathered debris, generally plateau-summit areas) for example: **BF,**MountBarrow[−41.3716,147.4102] Caine (1968).[82] The possible linkages between the labels and origin of **BF**/**SR** with respect to weathering processes[83] will not be discussed here. However, the description of the Falkland Islands **SR** by Charles Darwin in 1839 mentioned by Worsley[39] shows the importance of reporting field sites in the light of the sarsens stones and their 'solifluction' on the Marlborough Downs of southern England. Sarsens are seen iconically at Stonehenge (**AS,**Stonehenge[51.1788,−1.8261], where **AS** is a label for an archaeological or geoheritage site) and were painted by J.M.W. Turner in 1819 after a field visit in 1802. The sarsen stones, remnants of the Palaeogene rocks of southern England, have been revisited by Worsley[39] in the context of both geoheritage and stratigraphy. The sarsen's cross English Channel equivalents, the surface exposed silicified rocks (Oligocene silcretes) of the Forêt de Fontainbleu (Seine-et-Marne) of northern France that can be linked by outcrop at **TO**[48.4382,2.6285] to paintings by Cézanne.[84(p.90ff)]

14 | DISCUSSION

With the burgeoning information about 'periglacial environments' and the wider 'cryosphere',[4] questions arise about how we, as a scientific community, record our data, discuss information and make it available for workers of the future. The 'periglacial landforms of Europe'[14] is a part of this information expansion but could be helped by better specification of site information and photographic metadata. Murton[8] posits 'uncertainties about landscape evolution under cold, nonglacial conditions' with attention to lowland areas. This note suggests ways the literature about upland areas can be examined with reference to tors and rock glaciers. Site identification by [dLL] provides a simple way in which we can make a start to provide, digital locations for investigations and discussions about 'periglacial environments' or with reference to specific sites. This note shows ways in which data can be made more accessible and observations in general. Data made available as prior information in model building and testing helps reduce knowledge uncertainty[3] under varying conditions in space and over time (the 'sum over histories' approach). Explanations based on 'total geomorphological and geological history'[85] are rarely possible. However, maximising observational information and making them findable and available in discussion is of major importance in providing explanations of earth surface features. Revisits and re-interpretations of sites with new or revisited information is also important, as Worsley[46] shows with his investigation of Darwin's early fieldwork and Waltham[40] for the re-evaluation of Bretz and Lake Missoula.

15 | CONCLUSIONS

Using [dLL] geolocation allows landforms (or parts of landforms) to be linked to appropriate prior information in the literature. Comparing locations then allows sharing of information within specific landform domains and between topographic domains (via the FAIR principles). These effects are illustrated in the examples related to tors and rock glaciers. Increasing the information and explanatory content of papers would be aided by referencing *all* significant papers and by using the [dLL] identification of features following the FAIR principles. Inclusion of [dLL] data should become more generally used to identify locations, study sites, images and sampling points. The use of digraphs as short labels to identify landforms at [dLL] geolocations should encourage machine language searching processes in the future. Field meetings and site reporting are enhanced by open data and promote 'open discussion'. Primarily, paper and reports should include appropriate [dLL] wherever possible to allow future availability and compliance with FAIR data principles. Any location should have, for preference, a [dLL] label attached to sites, images, tables and dated items. Only in this way will data sources be available for the future investigations.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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