

Redefining the boundary between karst and pseudokarst: a discussion

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Abstract: Self and Mullan (1996) wish to redefine the concepts "**karst**" and "**pseudokarst**" in terms of purely physical characteristics rather than their traditional meaning which involves both landform and process. It is argued here that their usage of "karst" would be more appropriately termed "karst terrain" and that "karst" is best kept as a combination of terrain and process, with a process-based division into "true" karst and "pseudokarst" where this is feasible. If a separate term is wanted for features such as talus caves, which have a distinctive morphology as well as a separate process, then "quasikarst" is suggested.

INTRODUCTION

Self and Mullan (1996) refer to the diversity of existing definitions and classifications of karst, and perceive problems with the term "pseudokarst" being applied to some limestone terrains or to some limestone cave passages formed by processes other than dissolution. They therefore wish to redefine the concepts "**karst**" and "**pseudokarst**" in terms of purely physical characteristics rather than on the basis of their traditional meaning, which involves both landform and process elements.

THE CONCEPTS BEING DISCUSSED

Part of the confusion in the existing terminology, and in the recent discussion by Self and Mullan, exists because "**karst**" has been used and defined at several levels of meaning. The different concepts involved are:

Karst:	A union of terrain and process.
Karst Processes:	Traditionally solution, but includes other process as well. Some definitions put emphasis on underground removal of material by any process.
Karst Terrain:	A suite of characteristic physical features.
Karst feature:	A cave, doline, blind valley, karren, underground drainage etc.
Pseudokarst:	A union of terrain and process.
Pseudokarst processes:	Mechanical erosion, piping, mass movement and tectonics, phase change (lava tubes, glacier caves, thermokarst, ablation features), wave action (sea caves), mining, weathering processes, wind action.
Pseudokarst terrain:	A suite of physical features.
Pseudokarst feature:	A particular cave, sinkhole etc.

Depending on the author, or on the context, the word **Karst** when used on its own can sometimes mean the general concept, and sometimes only the terrain or only the process. In a discussion of terminology such as this care is needed to indicate just which concept one is referring to. In this discussion "**karst**" is used (on its own) to mean the complete concept - landform and process; "**karst terrain**" is used when discussing only the suite of observed physical features, and "**karst process**" in discussing the deduced origins. The same approach applies to "**pseudokarst**".

PRIOR USAGE

Karst.

To define "pseudokarst" one must first define "karst". As Self and Mullan (1996) indicate, there have been many and varied uses of the term "karst". However, most definitions cite reference both to landforms and to process. However, where authors define "karst" only as a landform, they are really referring to the concept of "karst terrain" rather than to the overall concept. Likewise, a definition of "karst" based purely on process would seem incomplete.

There seems little argument that the special landforms that characterise **karst terrain** include:

- (a) *on the surface*: various types of closed depression, stream sinks, springs and karren, and a lack of integrated surface drainage; and
- (b) *below the surface*: caves and an underground drainage.

Some authors would require that specific features (such as underground drainage, or closed depressions) be present, while other features (such as karren) are generally considered to be optional and not definitive where found on their own. Note that "underground drainage" refers both to a physical feature (the stream and its conduit) and to a process, so that including this in the definition of a "karst terrain" does imply genetic connotations. Also, the presence of underground drainage is commonly a deduction rather than a direct observation; which makes it less suitable for inclusion in a purely descriptive definition.

Traditionally, the dominant **karst process** has been stated as either "dissolution" or, less commonly, "underground erosion". As Self and Mullan point out, recent work has shown that dissolution is not the only process that occurs in karst terrains, nor is it necessarily the dominant process. None-the-less, the bulk of the world's karst terrains are found on soluble rocks, so dissolution **is** the characteristic process, and it seems

reasonable to use a special term ("pseudokarst") where this is not the case. Perhaps dissolution should now be regarded as the "initiating process" to allow for the possibility of other processes becoming dominant in later stages of the evolution of the landform.

In the past some definitions have specified limestone as the parent "karst rock", but this seems to have fallen out of favour. Such a definition leaves karst terrain on gypsum and other soluble rocks as candidates for "pseudokarst" and this approach was used by Sweeting (1972, p 306). This problem was addressed in Europe by Anelli (1963) with the introduction of a three-way division of karst terrains into: "**holokarst**" (or just "karst") developed by dissolution of limestone, "**parakarst**" formed by dissolution of other rocks, and "**pseudokarst**" for terrains developed by other processes. This usage has been summarised by Silvestru (1990), and has been used for many years as a basis for classification in the Speleological Abstracts published by the Union Internationale de Speleologie (UIS). The UIS Speleological Abstracts also use a term "**hypokarst**" for glacier caves and lava tubes. Philipp Häuselmann (pers. comm.) indicates that the term "hypokarst" was apparently coined by Cigna (details not supplied) for karst-like features formed by a process of phase change within a single material (melting of ice or solidification of lava), as distinct from "parakarst" which involves reaction of two components (rock and water) and "karst" which involves three components (rock, water and carbon-dioxide).

Unpublished reports are acknowledged as being unsatisfactory sources; however, a memorandum circulated by Quinlan in 1966 is of particular interest and so is summarised here. He sent out a request for definitions of both karst and pseudokarst, and compiled the responses from 18 North American karst scientists, along with translations of three European definitions. Most of them defined "**karst**" as both landform and process (dominantly dissolution), but a few also regarded underground drainage as critical. Only two specifically excluded dissolution: one defined karst purely as a terrain, and the other emphasised underground erosion by **any** process. Both these regarded "pseudokarst" as therefore being an unnecessary term. By contrast, another contributor specifically excluded underground drainage as the primary basis of the definition. Given the present-day emphasis on mechanical erosion in caves, it is notable that several respondents in 1966 emphasised that dissolution was not the only process, and Quinlan's own definition referred to "a group of processes - chiefly solution, but also including **solution-induced** suffosion, precipitation, corrosion, transportation, deposition, subsidence and collapse" [current author's emphasis]. Quinlan's definition, and classification was later published in an AAAS symposium (Quinlan, 1966), but the present author has not seen that paper.

Note that if "underground erosion" rather than "dissolution" is specified as the essential element of the karst process, then an important restriction is placed on the scope of "pseudokarst".

Most recent usage of "karst" has been similar to that of Quinlan's respondents; with an emphasis on both terrain and process. Self and Mullan cite a number of text-book definitions of karst, but say that only one gives a process-independent definition: that of Ford and Williams (1989). However, the quote they give from Ford and Williams (1989) is misleading. Ford and Williams define karst in the first paragraph of their book as "*Karst is a terrain with distinctive hydrology and landforms arising from a combination of high rock solubility and well developed secondary porosity*". The passage cited by Self and Mullan comes from the end of a paragraph on the following page in which Ford and Williams discuss the origin of the term in the *kras* region in Yugoslavia and its extrapolation to similar terrains elsewhere in the world. Ford and Williams are merely summarising the characteristic physical features of a **karst terrain** but as they have already defined **karst** as both a terrain and a process, this cannot be considered a general definition.

Pseudokarst.

Halliday (1960) was probably responsible for introducing the term "pseudokarst" into English-speaking and speleological circles. He refers to earlier usages, in Europe, dating back to the 1930s. However, in an unpublished memo in 1966, Quinlan claimed that the term was "first proposed by von Knebel (1906, p 182-183) with reference to the hydrology of certain lava terrains". Halliday (1960) used pseudokarst for "...features of non-solutional origin which are analogous to those of areas of karstic geomorphology".

Most of the contributors to Quinlan's unpublished memo in 1966 defined "pseudokarst" as karst landforms derived by a different (non-dissolutional) process, or forming in non-soluble rocks - which amounts to the same thing. A few said that "pseudokarst" was simply "non-karst" and the one who used a karst definition based purely on landform considered the term unnecessary, as did the one that defined the karst process as underground erosion by **any** means.

Authors who defined karst as being restricted to limestone rocks tended to class dissolutional features in other rocks as "pseudokarst" (e.g. Sweeting, 1972), but that approach seems to have been discontinued with non-limestone dissolution now included either in "karst" or in "parakarst".

One major objector to the use of pseudokarst for a range of non-dissolutional landforms was Otvos (1976). His objection was twofold: firstly a justified objection to the extension of the term by some people to minor features (such as solution pans) or to extreme cases, such as areas which lacked surface drainage but showed no other "karst" landforms; and secondly, one based on his feeling that "pseudokarst" should mimic not only the karst landforms, but also the process of underground erosion. On this basis he advocated that only thermokarst and landforms due to piping qualified as "pseudokarst", and excluded (as "non-karst") features such as glacier caves and lava tubes.

ETYMOLOGY

The prefix **pseudo** comes from a Greek word meaning "false, falsely". According to the Shorter Oxford English Dictionary, its use in scientific combinations is to indicate close or deceptive resemblance to the thing referred to, without real identity or affinity with it. This fits well with the existing usage of "pseudokarst" for landforms which look like karst landforms, but which differ in their origin (process) or fundamental composition (parent rock).

If a non-genetic term is required for landforms that are similar to karst but not quite the same in appearance, then the prefix **quasi** might be more suitable. **Quasi** is from a Latin word meaning "as if, almost". Thus in **quasi** the emphasis is on the similarity rather than on the (possibly hidden) difference implied by **pseudo**.

In the European term "parakarst", **para** comes from a Greek word meaning "by the side of, beside". It does not come from the Latin word meaning "protection" (as does parachute). The prefix **hypo** comes from the Greek root meaning "under", but which is used in modern formations in the sense "under, beneath, below" and also "to some extent, slightly, somewhat". In "hypokarst" it seems to imply "less complex" or "fewer components" than the processes of parakarst and karst.

The etymology of **karst** has been described by others and does not help in the definition as it comes from a place name, which in turn is from a word meaning simply "rock".

DISCUSSION

In the following discussion it is advocated that "**karst**" should be used in the sense of both a terrain and a process, and that "**karst terrain**" should be used where a non-genetic descriptive term is needed. Quinlan is followed in defining the **karst process** as "dissolution and other dissolution-induced processes" - these other processes can also operate in pseudokarst, but there they are not "dissolution-induced". "**Pseudokarst**" will be used in its traditional sense of "a karst terrain that has formed by non-dissolutional process", with the addition that the processes are also "not dissolution-induced".

However they are defined, the distinction between "karst" and "pseudokarst" is a "bald-hairy" one - in that there is a continuum of sites showing the full range from obviously dissolution dominated processes to completely non-dissolutional processes. The boundary must be an arbitrary and subjective one and some borderline sites will be difficult to classify. This problem would also occur with Self and Mullan's attempt to distinguish the two types on purely physical character - all gradations occur. If "pseudokarst" is defined on the basis of parent rock it also creates "borderline" problems when, for instance, considering karst terrains on silicate rocks, which are soluble in some environments but not so in others.

Self and Mullan (1996) argue that "karst" should be redefined in a non-genetic manner. Their reasons are the diversity of existing definitions and classifications of karst, and perceived problems with the term "pseudokarst" being applied to some limestone terrains or to some limestone cave passages formed by processes other than dissolution. There certainly have been arguments about the most appropriate definition of "karst" but, none the less, the majority of usages have included both terrain and process. To try and restrict the term's usage to only terrain will add to the confusion. If a river passage in a cave can be shown to have formed entirely by mechanical (or other non-dissolutional) processes then this author would argue that referring to that passage as "pseudokarst" is not "absurd" but, on the contrary, a useful way of emphasising the lack of dissolution. The host area as a whole would still, presumably, be referred to as "karst", as it would be a "karst terrain", and dissolution would have been the distinguishing process in its origin. In fact, it must be suspected that even such supposedly non-dissolutional major stream passages **originated** as dissolutional tubes (how else?) and that dissolution continues to be active, even though now overshadowed by mechanical erosion.

Self and Mullan say that "identical landforms ... should be classed together". Agreed - but class them as "karst terrain" and then use the terms "karst" and "pseudokarst" (and its sub-classes) to subdivide the terrains on the basis of process where process can be deduced. They also say that genetic classifications only hinder understanding. This is only true if classifications are applied too early in a study. Describe firstly the physical features, decide whether they warrant being classed as "karst terrain" and, only then, try to deduce and classify the processes. In some cases the processes acting in an area may not be obvious in which case call it a "karst terrain of uncertain origin". If there are multiple processes, and the area falls near the ill-defined boundary between "karst" and "pseudokarst", then it is best not to force it into one category or the other, but to describe it as a "karst terrain formed by both karst and pseudokarst processes" and give the details. Classification is not everything.

Self and Mullan give examples of two problem areas. The initial problem with the Cotswolds would seem to be whether the area even qualifies as a karst terrain. Gull caves are small and not common, and, although they mention sinkholes, it seems that they are fairly rare. Hence the area is marginal as "karst terrain". The gulls are formed by non-dissolutional processes, and therefore could be called pseudokarst **features** even if one does not count the region as a karst **terrain**. There is no problem with application of the existing process-based usages of "karst" and "pseudokarst" here. It is irrelevant that the area is developed on limestone, as that parent-rock criterion is now seldom used to define "karst".

The Northumberland area would seem to have a range of karst **features**, and so qualifies as karst **terrain**. If the deduced process is mechanical erosion following preparation by chemical weathering then it qualifies as "pseudokarst" - though, as one could argue that chemical weathering involves some dissolution, then it lies closer to the karst-pseudokarst boundary than other areas with more distinctive processes. Thus the Northumberland area would be classed as "karst terrain produced by pseudokarst processes" or "pseudokarst" for short.

Finally, having argued for a redefinition of karst as a terrain without genetic connotations, Self and Mullan say "...what then of pseudokarst". They then attempt to redefine it in non-genetic terms as "features that are superficially similar to karst, but have some unique element that is not found in karst". Presumably they are talking about physical elements. They then spoil their entire argument by producing a list of "pseudokarst features" that they define in mainly genetic terms. Initially, for tectonic caves and gull caves, they try to justify the non-genetic approach by citing the fit features of the walls - but these have been noted in the descriptions primarily because they are indisputable evidence of the process. They then go on to include lava caves because they "form while the host basaltic magma is solidifying, and are therefore primary features", and sea caves due to the "surging action of waves". These are both blatantly genetic definitions.

It must be agreed that talus caves have a distinctive morphology (the cavities are essentially an "inter-granular porosity" on a huge scale!) and they probably deserve a classification separate from both karst and pseudokarst. Wind and weathering caves are usually small features and invoke that other contentious argument: namely "the distinction between a cave and a rock-shelter". It was an interesting coincidence that a paper by Hunt (1996) describing "tafoni" appeared next to that of Self and Mullan (1996). Many speleologists would argue that the tafoni described by Hunt would not even qualify as caves, let alone "karst" or "pseudokarst". For referring to features, such as talus caves and tafoni, that are distinct in appearance from both karst and pseudokarst caves, this author would suggest a separate term: **quasikarst**.

CONCLUSION

Self and Mullan are worried by the need for a non-genetic term for karst features and landforms. It is suggested that rather than redefine "karst" they should adopt the term "karst terrain", and retain "karst" in its generally used connotation of both a terrain and a process (perhaps modifying the process definition to include both "dissolution" and "other dissolution-induced processes"). The existing distinction between karst processes and pseudokarst processes is a very useful one and should not be converted to one based on physical features. Where a karst terrain exists and the processes are clear-cut one can use "karst" as a shorthand for "karst terrain formed by karst processes" and "pseudokarst" as shorthand for "karst terrain formed by pseudokarstic processes". Where the processes are unknown or complex, then a description such as "karst terrain of uncertain/complex origin" can be used. Where an area fails to qualify as karst terrain, an individual feature can still be referred to as (for example) a "pseudokarst cave", or a "karst doline" if its genesis is obvious. If not, then it should just be called a cave, or a closed depression, or whatever, and described as clearly and completely as possible.

Some features such as rock shelters of various origins and talus caves, are sufficiently different to perhaps be excluded from the karst nomenclature entirely. Though, as these may still have speleological or archaeological interest, they will continue to be described in the karst and cave literature. If a separate term is considered necessary for these "karst-like" features then adoption of the term "quasikarst" should be considered.

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Postscript

In the same issue that contained this paper, the *Forum* section of *Cave and Karst Science* **24(2)**: pp. 91-93, had several letters discussing the nomenclature of pseudokarst. Additional letters appeared in *Cave and Karst Science* **25(1)**: pp. 47-48 (1998), and included a discussion and table of terms (hyperkarst, karst, parakarst, hypokarst, and pseudokarst) taken from two papers by Arrigo Cigna: Cigna, A.A., 1978: A classification of karstic phenomena. *International Journal of Speleology*. Vol 10, 3-9. Cigna, A.A., 1985: Some remarks on phase equilibria of evaporites and other karstifiable rocks. *Le Grotte d'Italia*. Vol (4) XII, 201-208.