Available online at scholarcommons.usf.edu/ijis/ & www.ijis.speleo.it

International Journal of Speleology

Official Journal of Union Internationale de Spéléologie

Appropriate terminology for karst-like phenomena: the problem with 'pseudokarst'

Rolan Eberhard^{1*} and Chris Sharples²

¹ Resource Management and Conservation Division, Department of Primary Industries, Parks, Water and Environment, Tasmania, GPO Box 44, 134 Macquarie Street, Hobart, Tasmania 7000, Australia

² School of Geography & Environmental Studies (Spatial Science; Private Bag 76), University of Tasmania, Hobart, Tasmania, 7001, Australia

Abstract: The practice of referring to certain morphologically karst-like phenomena as 'pseudokarst' is problematic, because it ignores basic principles of sound classification, logical naming conventions and accepted geomorphic classifications and terminology. These problems have compounded the difficulty in establishing an accepted classification of 'pseudokarst' types. The practice embodies a karst-centric perspective which should be avoided in favour of using conventional geomorphic terminology for non-karstic features. We illustrate this by providing existing conventional terms for many 'pseudokarst' types reported in the literature.

Keywords: karst; pseudokarst; landform classification; geomorphology; Tasmania

Received 19 November 2012; Revised 5 February 2013; Accepted 6 February 2013

Citation: Eberhard R. and Sharples C., 2013. Appropriate terminology for karst-like phenomena: the problem with 'pseudokarst'. *International Journal of Speleology*, 42 (2), 109-113. Tampa, FL (USA) ISSN 0392-6672 <http://dx.doi.org/10.5038/1827-806X.42.2.2>

Karst is defined with reference to the enhanced solubility of certain rock types in natural waters, the consequent importance of aqueous dissolution and precipitation as dominant geomorphic drivers, and the resultant characteristic landforms and hydrology (Jennings, 1985; Gillieson, 1996; Ford & Williams, 2007;). This is consistent with accepted practice for classifying landforms according to morphogenetic criteria, recognising that similar morphologies can result from quite different geomorphic processes. However the alternatives of either purely morphology-based or purely genesis-based approaches to landform classification would not be satisfactory for elucidating the history of landscapes, which is a fundamental aim of geomorphology.

Despite near-universal acceptance of a morphogenetic definition of karst, we note a tendency to apply morphology-based criteria to accommodate discussion of various non-karstic but karst-like phenomena (Grimes, 1975; Vitek, 1987; Halliday, 2004, 2007; CRCCS, 2008). We refer to the problematic term 'pseudokarst'. Aspects of this term are discussed in several papers and some criticisms have been made previously. Otvos (1976) argued that morphology alone was not an adequate basis for designating 'pseudokarst', and recommended that the term should be applied only in the case of piping and 'thermokarst' forms. The latter term has been used with reference both to cavities in glaciers and depressions due to melting of ground ice in permafrost. Although not always explicitly used as a class of 'pseudokarst' (e.g.

French, 2007), 'thermokarst' likewise has misleading connotations of a karstic dimension to non-karstic phenomena. Cigna (1973, 2008) stressed physico-chemical criteria in differentiating between karstic and karst-like terrains, recognising a spectrum of 'karstic' types (hyperkarst, karst, parakarst, hypokarst, pseudokarst). The definitional basis of karst and 'pseudokarst' has also been raised in the context of cavernous silicate terrain, informing suggestions that karst itself requires a new definition (Martini, 2004). Simmert (2011) expressed reservations at using 'pseudo' as a prefix for karst-like phenomena, but did not propose an alternative. We contend that these contributions do not resolve problems of a more fundamental nature which we identify below.

Specifically, we argue that the term 'pseudokarst' is (a) poor classification practice *in principle*; (b) unnecessarily duplicates mainstream approaches to landform classification; and (c) is a karst-centric terminology for non-karstic phenomena. Each of these objections is discussed below.

(a) Poor classification practice

We propose that scientifically-based classifications should be and generally are underpinned by certain basic principles, including that: (1) a demonstrable need exists for the classification; (2) the scope of features included has an objective basis; (3) categories within the classification are mutually exclusive; and (4) the constituent elements are differentiated and named

*Rolan.Eberhard@dpipwe.tas.gov.au

according to what they *are*, not according to what they *are not*. The class of 'pseudokarst' fails to comply with each of these principles. There is no demonstrable need for the term because the landforms concerned are already logically classified using conventional geomorphic terminology, which adequately covers both their morphogenetic classification and their morphological similarities to karst (see below). The scope of 'pseudokarst' is arbitrary, lacking an objective basis because it is generally concerned with a narrow subjectively-defined range of karst-like landforms, most commonly although not exclusively caves and enclosed depressions, that ignores much of the diversity of actual karstic landforms. Categories proposed for classifying 'pseudokarst' tend not to be mutually exclusive, due to an emphasis on similarities in form between otherwise very different features as a primary defining characteristic. This can lead to confusion and awkward classification hierarchies as noted further in (b) below. Finally, as a means of classifying landforms 'pseudokarst' (literally 'false karst') is not a valid form of differentiation and naming, since it lacks meaning in itself without reference to karst. That is to say, the notion of 'pseudokarst' classifies things according to what they *are not*, rather than according to what they *are*. This problem was recognised by Simmert (2011); it cannot be a logical basis for the classification of natural phenomena.

(b) Unnecessarily duplication of mainstream geomorphic classifications

Whereas 'pseudokarst' as an umbrella term is typically defined primarily with reference to morphology, 'pseudokarst' proponents classify sub-types according to a sometimes confusing mix of form, process and fabric. Grimes (1975) adopted a process-based classification depending on whether eroded material is transported in a solid, liquid or gaseous state. Vitek (1987) proposed a classification based on both morphology and scale. Halliday (2004, 2007) recognised some mainly process-based categories, such as 'rheogenic pseudokarst' (lava flow forms), some mainly morphology-based categories, such as 'crevice pseudokarst' (fractured volcanic rocks, sea caves, glacial crevasses) and some mainly fabric-based categories, such as 'talus pseudokarst' (interstitial cavities due to weathering or mass movement) and 'compaction pseudokarst' (landslide and avalanche deposit forms). In some cases trivial parallels have been invoked while ignoring fundamental differences in scale, process and context. For example, Halliday (2004) implied that the 'water-filled cavern beneath the Ross Ice Shelf' (i.e. the underlying ocean) is a form of 'glacier pseudokarst'. No apparent consensus on a unifying classification of 'pseudokarst' types has emerged.

Consequently, literature on 'pseudokarst' often relies strongly on conventional geomorphic terminology and explanations, especially at the level of case studies of specific landforms. This is an entirely logical approach which we consider implicitly acknowledges the confusion that arises from the exclusive use

of 'pseudokarst' terminology. Some recent papers reference 'pseudokarst' only as a keyword (e.g. Grimes, 2006; Smith, 2007). On the other hand, new terms have been proposed for features which can be described more simply using existing terminology. A selection of such terms and conventional geomorphic terms for the same features is listed at Table 1. This illustrates our point that appropriate terminology and classifications are already available for the relevant phenomena, and we believe these should be used. The fact that the term 'pseudokarst' is defined in key earth science references (e.g. Neuendorf et al., 2005) indicates a history of use but is not justification in itself.

The complexities and confusions (above) that arise when attempting to make non-karstic phenomena fit into an arbitrarily-defined category such as 'pseudokarst' underscore our assertion that this is poor classification practice which unnecessarily duplicates existing classifications. This is reinforced by Figures 1 to 3, which show morphologically karst-like landforms at two sites in Tasmania. Both sites have been cited as examples of 'pseudokarst', yet are more informatively described by conventional terminology.

(c) 'Pseudokarst' is karst-centric terminology

The term 'pseudokarst' embodies an assumption that karst is an appropriate benchmark for defining many non-karstic phenomena. There is no objective basis for this very karst-centric perspective, which has been pursued under the auspices of the International Union of Speleology Pseudokarst Commission, although the term itself was reportedly first used by the geologist von Knebel (1906) with reference to lava features, apparently in an attempt to clarify that

Fig. 1. View out of a wave-excavated sea cave that developed along joint fractures in Devonian-age granite at Deep Glen Bay, southeastern Tasmania. This cave has formed by a non-karstic marine erosion process, but it also has elements of true (constructional) karst, namely stalactites and large tufa sheets (one visible just outside the cave entrance) which have precipitated out of carbonate-rich groundwater percolating from overlying calcareous siltstone units. Thus, this site encapsulates a coastal landform with both karstic (solutionally-derived carbonate speleothems) and non-karstic but morphologically karst-like (cavernous morphology) components. To designate it as 'pseudokarst' would entail potential to confuse the respective features and processes (photo by C. Sharples).

Table 1. Conventional terminology for selected 'pseudokarst' types.

Geomorphic domain	'Pseudokarst' type	Geomorphic process	Conventional terms
Marine/coastal	Pseudokarst abrasional cave (Urban & Oteska-Budzyn, 1998); littoral crevice pseudokarst (Halliday, 2007).	Enlargement of fractures or susceptible beds, primarily through mechanical erosion driven by wave action.	Marine cave (Trenhaile, 1987); sea cave (Woodroffe, 2002).
Volcanic	Syngenetic pseudokarst (Cigna 1973); pseudokarst volcanic cave (Urban & Oteska-Budzyn, 1998); rheogenic pseudokarst (Halliday, 2007).	Primary voids in volcanic rocks; surficial cooling of lava flows; secondary voids in lava following decomposition of covered organisms.	Hollow hornito; hollow tumuli; lava cave; lava mould cave; lava tube; pit crater (Field, 2002; Neuendorf et al., 2005).
Glacial	Glacier pseudokarst (Halliday, 2007; Otvos, 1976).	Meltwater caves and streams within glaciers and firn, including geothermal ablation caves on volcanoes.	Glacier cave; meltwater stream; meltwater tunnel; moulin; subglacial tunnel (Field, 2002; Sugden & John, 1976).
Periglacial	Permafrost pseudokarst (Halliday 2007); thermokarst (French, 2007).	Melting of ground ice.	Collapsed frost blister; collapsed pingo; ice wedge trough; thaw depression; thaw lake (French, 2007).
Aeolian	Deflation pseudokarst (Davies & LeGrand, 1972 cited by Otvos, 1976).	Translocation of unconsolidated sand or clay by wind action.	Deflation basin; deflation hollow; deflation lake (Neuendorf et al., 2005).
Mass movement	Pseudokarst sinkhole (Vitek, 1987).	Subsidence of regolith materials into cavities formed by mass movement or mechanical removal of interstitial sediment.	Sink hole (as simple descriptive term) (Field, 2002; Twidale, 1987); slump basin (Neuendorf et al., 2005); enclosed depression.
	Pseudokarst crevice cave (Urban & Oteska-Budzyn, 1998; Vitek, 1987); pseudokarst crack (Galdenzi, 2011).	Toppling, sliding or rotation of rock or regolith along planes of weakness; dilation along fractures by erosional unloading or incision.	Dilation cave; dilation fracture; fissure cave; tectonic cave (Field, 2002).
	Pseudokarst talus-type cave ('pseudocaves') (Vitek, 1987); pseudokarst boulder (talus) type cave (Urban & Oteska-Budzyn, 1998); talus pseudokarst (Halliday, 2007).	Rockfall or fracturing of rock masses yielding accumulations of coarse clastic deposits with interstitial cavities.	Boulder cave; talus cave (Neuendorf et al., 2005).
Soil piping	Piping pseudokarst (De Waele et al., 2008; Sanna et al., 2011; Otvos, 1976); Badlands and piping pseudokarst (Halliday, 2007).	Progressive removal of dispersive clays and clastic particles within weakly consolidated sediment by shallow ground water movement.	Soil pipe; soil piping (Jones, 1987).
Weathering	Pseudokarst cave niche, bedding-type cave and fissure-type cave; pseudokarst rock perforations, lapies and karren (Vitek, 1987); pseudokarst fissure cave and bedding cave (Urban & Oteska-Budzyn, 1998).	Wide variety of landforms due to differential weathering by combined solutional and mechanical processes (Young & Young, 1992, pp. 69-77), typically in granitic rocks, quartzite and sandstone.	Cave; karren; lapies; natural arch; natural bridge; pinnacle; rock tower; rock pillar; ruiniform landforms; tafoni; tafoni cave (Twidale, 1982; Young & Young, 1992). Note: some examples of these landforms arguably constitute karst sensu stricto in that solutional processes are dominant (Jennings, 1983; Wray, 1997).
	Pseudokarst speleothem (Pavuzs, 2011).	Solutional translocation of minerals by groundwater, deposited as concretions in caves.	Speleothem; stalactite; stalagmite (Hill & Forti, 1997). Note: standard karst terminology applicable where precipitates derive primarily from solution of bedrock.
Anthropogenic	Consequent pseudokarst (Halliday, 2007); surface pseudokarst mesoforms (Galdenzi, 2011)	Human excavation (e.g. quarries, fire pits) and indirect effects of this (e.g. collapse or subsidence into underground mines).	Mine; mine-induced subsidence; pit; quarry.

certain features were not actual karst (Halliday, 2004; Simmert, 2011). We note that to varying degrees virtually all landforms including karstic ones have morphological analogues developed under different process regimes. Therefore, it serves no purpose to blur the distinction between features with very different process histories by focussing on superficial similarities of form, as in the example of 'pseudokarst'.

The same principle applied more widely would imply scope for unlimited classes of 'pseudo' features. For example vulcanologists could describe karst caves as 'pseudo-lava tubes' which would clearly be an absurd outcome yet is based on an equivalent logic to that which underpins the notion of 'pseudokarst'.

In summary, 'pseudokarst' is not an appropriate umbrella term for describing morphologically karst-like phenomena; nor does it provide an appropriate framework for classifying the relevant phenomena, as these are more usefully covered by established geomorphic classifications and terminology. The term 'pseudokarst' makes little sense from any geomorphic perspective other than a very karst-centric one, and as such does not complement or extend more broadly

Fig. 2. Contour map of Badger Creek enclosed depression, southwest Tasmania. The depression occupies an area of nine hectares and has no surface outlet, engulfing several streams. Located within an area of predominantly siliceous Late Precambrian to Ordovician rocks, the presence of karstified limestone beneath Quaternary sediments which cover the floor of the depression (elevation 300 m asl) cannot be excluded on present geological evidence. Irrespective of this possibility, the depression does not appear to have become fully enclosed until mechanical slope failure blocked a narrow canyon that formerly cut through the strike ridge on its western side (see Figure 3). The site illustrates morphologically karst-like attributes and may even be partially karstic, reinforcing the importance of avoiding ambiguous terminology such as 'pseudokarst' in characterising the landforms.

Fig. 3. Aerial view of the former surface outlet of the Badger Creek enclosed depression, as shown in Figure 2. The strike ridge in the foreground is formed in coarse siliceous conglomerate and defines the western margin of the depression. The ridge was originally truncated by a gorge, but subsequent infilling by blocky debris has reduced the surface expression of this to a shallow saddle. Streams coalescing on the forested floor of the depression disappear underground into a boulder cave at the base of a 40 m high cliff in the centre of the photo. The underground course of the stream cannot be followed for any great distance, but presumably approximates the alignment of the watercourse prior to collapse of the canyon (photo by R. Eberhard).

accepted classifications and terminology, as used amongst the wider community of geomorphologists. Indeed, the use of the term 'pseudokarst' has arguably contributed to a lack of clarity regarding the scope of (true) karst studies, as manifest in the debate regarding whether solutional landforms in silicate rocks are karst or 'pseudokarst' (Wray, 1997; Martini, 2004; Aubrecht et al., 2011; Sauro et al., 2012). It seems possible that the perceived importance in some quarters of maintaining a distinction between karst and 'pseudokarst' has delayed broader acceptance of solutional landforms in silicates as a valid form of karst.

In rejecting the term 'pseudokarst' we do not dismiss the importance of scientifically documenting the wide range of landforms with karst-like attributes, or the validity of adopting a thematic morphological approach to this, provided it is done using language that does not obscure fundamental geomorphic differences. Thus for example the use of the morphological themes of 'caves' or 'enclosed depressions' developed through a variety of processes including karst achieves the same purpose as that of 'pseudokarst', and does so using broadly accepted terminology that complies with good classification practice. We contend that relevant studies will extend their scope and impact by adopting this approach.

REFERENCES

- Aubrecht R., Láncoz T., Gregor M., Schlögl J., Šmída B., Liščák P., Brewer-Carías Ch. & Vlček L., 2011 - *Sandstone caves on Venezuelan tepuis: Return to pseudokarst?* *Geomorphology*, **132**: 351-365. <http://dx.doi.org/10.1016/j.geomorph.2011.05.023>
- Cigna A.A., 1973 - *A classification of karstic phenomena*. *International Journal of Speleology*, **10**: 3-9. <http://dx.doi.org/10.5038/1827-806X.10.1.1>
- Cigna A.A., 2008 - *The family of karst phenomena: some physical-chemical parameters of some rocks concerned outside the classical karst*. *Proceedings of the 10th International Symposium on Pseudokarst*, 29 April – 2 May 2008, Gorizia, Italy, Centro Ricerche Carsiche 'Carlo Seppenhöfer', p. 101-112.
- CRCCS, 2008 - *Proceedings of the 10th International Symposium on Pseudokarst*. 29 April – 2 May 2008, Gorizia, Italy, Centro Ricerche Carsiche 'Carlo Seppenhöfer', 175 p.
- Davies W.E. & LeGrand H.E., 1972 - *Karst of the United States*. In: Herak M. & Springfield V.T. (Eds.), *Karst*. New York: Elsevier: 467-506.
- De Waele J., Sanna L. & Rossi A., 2008 - *Pseudokarstic cavities in pyroclastic rocks: some examples from North Sardinia*. *Proceedings of the 10th International Symposium on Pseudokarst*, 29 April-2 May 2008, Gorizia, Italy, Centro Ricerche Carsiche 'Carlo Seppenhöfer', p. 53-62.
- Field M.S., 2002 - *A Lexicon of Cave and Karst Terminology with Special Reference to Environmental Karst Hydrology*. United States Environmental Protection Agency, Washington, 214 p.
- French H.M., 2007 - *The Periglacial Environment*. 3rd ed., John Wiley & Sons Ltd., Chichester, UK, 478 p.
- Ford D.C. & Williams P.W., 2007 - *Karst Geomorphology and Hydrology*. 2nd ed., John Wiley & Sons Ltd., Chichester, UK, 576 p.
- Galdenzi S., 2011 - *Pseudo karst landforms in the Adriatic side of north-east Apennine (Italy)*. *Proceedings of the 11th International Symposium on Pseudokarst*, 12-16 May 2010, Saupsdorf, Germany, published by Höhlen-und Karstforschung, Dresden, p. 56-71.
- Gillieson D., 1996 - *Caves: Processes, Development and Management*. Blackwell Publishers Inc., Oxford, 324 p.
- Grimes K.G., 1975 - *Pseudokarst: definition and types*. *Proceedings of the 10th Biennial Conference*, Australian Speleological Federation, Brisbane.
- Grimes K.G., 2006 - *A small cave in a basalt dyke, Mt. Fyans, Victoria, Australia*. *Helictite*, **39 (1)**: 17-20.
- Halliday W.R., 2004 - *Pseudokarst*. In: Gunn J. (Ed.), *Encyclopedia of Caves and Karst Science*. New York and London: Fitzroy Dearborn: 604-608.
- Halliday W.R., 2007 - *Pseudokarst in the 21st century*. *Journal of Cave and Karst Studies*, **69**: 103-113.
- Hill C. & Forti P., 1997 - *Cave Minerals of the World*. 2nd ed., National Speleological Society Inc., Huntsville, U.S.A., 463 p.
- Jennings J.N., 1983 - *Sandstone karst or pseudo-karst?* In: Young R.W. & Nanson G.N. (Eds.), *Aspects of Australian Sandstone Landscapes*. Australia & New Zealand Geomorphology Group, Wollongong, p. 21-30.
- Jennings J.N., 1985 - *Karst Geomorphology*. Basil Blackwell, Oxford, 293 p.
- Jones J.A.A., 1987 - *The effects of soil piping on contributing areas and erosion patterns*. *Earth Surface Processes and Landforms*, **12**: 229-248. <http://dx.doi.org/10.1002/esp.3290120303>
- Martini J., 2004 - *Silicate karst*. In: Gunn J. (Ed.), *Encyclopedia of Caves and Karst Science*. New York and London: Fitzroy Dearborn: 649-653.
- Neuendorf K.E., Mehl J.P. & Jackson J.A. (Eds.), 2005 - *Glossary of Geology*. 5th ed., American Geological Institute, Alexandria, Virginia, 779 p.
- Otvos E.G., 1976 - *Pseudokarst and pseudokarst terrains: problems of terminology*. *Geological Society of America Bulletin*, **87 (7)**: 1021-1027. [http://dx.doi.org/10.1130/0016-7606\(1976\)87<1021:PAPTPO>2.0.CO;2](http://dx.doi.org/10.1130/0016-7606(1976)87<1021:PAPTPO>2.0.CO;2)
- Pavuz R., 2011 - *A short treatise on Austrian Pseudokarst-Speleothems*. *Proceedings of the 11th International Symposium on Pseudokarst*, 12-16 May 2010, Saupsdorf, Germany, published by Höhlen-und Karstforschung, Dresden, p. 83-90.

- Sanna L., De Waele J. & Cabras S., 2011 - *Two examples of pseudokarst features in South Supramonte (Sardinia, Italy)*. Proceedings of the 11th International Symposium on Pseudokarst, 12-16 May 2010, Saupsdorf, Germany, published by Höhlen-und Karstforschung, Dresden, p. 92-96.
- Sauro F., Piccini L., Mecchia M., De Waele J., 2012 - *Comment on "Sandstone caves on Venezuelan tepuis: Return to pseudokarst?" by R. Aubrecht, T. Lánczos, M. Gregor, J. Schlögl, B. Smida, P. Liscák, Ch. Brewer-Carías, L. Vlcek*, *Geomorphology* 132(2011), 351-365. *Geomorphology* (2012). <http://dx.doi.org/10.1016/j.geomorph.2012.11.015>
- Simmert H., 2011 - *What is Pseudokarst?* Proceedings of the 11th International Symposium on Pseudokarst, 12-16 May 2010, Saupsdorf, Germany, published by Höhlen-und Karstforschung, Dresden, p. 96-100.
- Smith G.K., 2007 - *Tectonic and talus caves at Pilchers Mountain, New South Wales*. *Helictite*, **40 (1)**: 11-20.
- Sugden D.E. & John B.S., 1976 - *Glaciers and Landscape: A Geomorphological Approach*. Edward Arnold, London, 376 p.
- Trenhaile H., 1987 - *The Geomorphology of Rock Coasts*. Clarendon Press, Oxford, 400 p.
- Twidale C.R., 1982 - *Granite Landforms*. Elsevier, New York, 372 p.
- Twidale C.R., 1987 - *Sinkholes (dolines) in laterised sediments, western Sturt Plateau, Northern Territory, Australia*. *Geomorphology*, **1**: 33-52. [http://dx.doi.org/10.1016/0169-555X\(87\)90005-5](http://dx.doi.org/10.1016/0169-555X(87)90005-5)
- Urban J. & Oteska-Budzyn J., 1998 - *Geodiversity of pseudokarst caves as the reason for their scientific importance and motive of protection*. *Geologica Balcanica*, **28 (3-4)**: 163-166.
- Vitek J., 1987 - *Classification of pseudokarst forms in Czechoslovakia*. *International Journal of Speleology*, **13**: 1-18. <http://dx.doi.org/10.5038/1827-806X.13.1.1>
- Wray R.A.L., 1997 - *Quartzite dissolution: karst or pseudokarst*. *Cave and Karst Science*, **24 (2)**: 81-86.
- Woodroffe C.D., 2002 - *Coasts: Form, Process and Evolution*. Cambridge University Press, 640 p.
- Young R. & Young A., 1992 - *Sandstone Landforms*. Springer-Verlag, Berlin, 163 p. <http://dx.doi.org/10.1007/978-3-642-76588-9>