



Turloughs and tiankengs: distinctive doline forms

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Abstract

Tiankengs lie at one extreme of the collapse doline spectrum, and a key question is whether there is a distinctive ‘tiankeng process’ or whether the distinction is purely morphological. At the opposite end of the doline spectrum, the turloughs of Ireland are broad closed depressions with seasonal lakes. They may be differentiated from poljes by their smaller dimensions, gentler surrounding slopes and processes of formation. In particular, turloughs are only found in areas where there are glacial deposits and are, at least in part, glaciokarstic landforms whereas poljes occur in many climatic zones and their locations frequently demonstrate a structural influence. Turloughs have been recognised by the European Union as special karst landforms with a distinctive vegetation assemblage, although the term is not widely used because, with one exception, they are confined to Ireland. There are clear parallels with ‘tiankeng’ the majority of which are in China and which are distinguished from collapse dolines by their large size, and special processes of formation. It is argued that the terms ‘turlough’ and ‘tiankeng’ should both become established in the karst geomorphology lexicon.

Keywords: turlough, tiankeng, karst, Ireland, terminology.

Introduction

As discussed in other papers in this volume, the term *tiankeng* (roughly meaning *sky hole*) is used in Chinese to describe particularly large dolines formed by collapse. Zhu and Chen (this volume) propose that there is a distinction between ‘normal’ and ‘giant’ dolines, and that the term *tiankeng* should be applied to all of the world’s great dolines, not just those in China. Tiankengs clearly lie at one extreme of the collapse doline spectrum, and other papers in this volume examine the question whether there is a distinctive ‘tiankeng process’ or whether the distinction is purely morphological. The present paper aims to provide some insights from a lateral view of turloughs, which are considered to lie at the other extreme of the doline spectrum, being broad, shallow, depressions that are probably polygenetic in origin.

Turlough definition

The word *turlough* is commonly reported as being derived from the Irish Gaelic *tuar lough*, meaning a dry lake. However, Coxon (1986), in the most detailed work undertaken on these features, notes that the Gaelic word for *dry* is *tur* and that *tuar* translates as *pasture land*. There are similarities here with the etymology of the word *polje* which translates as a *field*, but has been used in a different sense by karst scientists. It is interesting that the local name for the only turlough recognised outside of Ireland (Pant-y-llyn, in South Wales) has a similar etymology, being translated as *field that is a lake* (Hardwick and Gunn, 1995). An aerial view of a turlough near Ballyshannon in County Donegal, Ireland (Fig. 1) provides an illustration of how this naming has come about. The bare ground that surrounds the lake marks the

maximum area of inundation and shows that the turlough is in a relatively early stage of its draining cycle. However, walls can be seen extending across the area that is still inundated and these will delimit fields when the lake finally dries up.



Fig. 1. Turlough near Ballyshannon, County Donegal, Ireland. (Photo: Richard Watson)

Turloughs are defined primarily on the basis of their hydrology and ecology, although it is clear that they are also karst landforms. For example, in Guidance Document no. GW9 of the Irish Working Group on Groundwater Sub-committee on Turloughs (URL 1, undated) a turlough is defined as “A topographic depression in karst which is intermittently inundated on an annual basis, mainly from groundwater, and which has a substrate and/or ecological communities characteristic of wetlands”. Hydrologically the key feature is the lake itself, which is:

- ephemeral, the majority being seasonal with an autumn fill cycle that is commonly rapid (hours to days) and a late spring to early summer drain cycle that may take several weeks; Coxon (1986, 1987a, 1987b) suggests that the lake must be at least 0.5 m deep at its maximum, and that most

turloughs dry completely each year although some contain residual pools;

- fed partly direct precipitation onto the depression in which it is located but primarily by groundwater which commonly enters from discrete conduits; the water chemistry reflects the groundwater source being close to saturation with respect to calcium carbonate;

- in its natural state has no natural surface outlet but drains via swallow holes or by estavelles; however, some turloughs have been partly drained to improve agricultural productivity.

Ecologically, turloughs are defined by their vegetation communities which show a distinct zonation determined by water depth and the frequency and duration of filling. Turloughs are listed as priority habitats under Annex 1 of the European Union (EU) Habitats Directive (92/43/EEC; Habitat 3180), and are listed as Groundwater Dependent Terrestrial Ecosystems under the EU Water Framework Directive. Many have been designated as Special Areas of Conservation, the highest level of protection of any natural site in EU countries.

Turloughs as landforms

In contrast to the relative ease with which turloughs can be described hydrologically and ecologically there are many difficulties in understanding their geomorphology. A particular problem is that most descriptions focus on the area inundated by water, and the topographic catchment of that area is rarely mentioned. An exception is Guidance Document no. GW9 (URL 1) in which it is suggested that turlough catchments can be divided into two broad types: (a) those where groundwater flow is shallow and entirely within the epikarst and (b) those where groundwater flow is deeper and more complex. The catchment for type a turloughs is likely to be local but type b turloughs are part of a larger groundwater system and may receive recharge from losing and sinking streams some distance away from the topographic catchment of the depression in which the lake is formed.

Turloughs are most commonly found in lowland areas where there is a cover of glacial drift and relatively little local relief. Indeed, Williams (1964, 1970) argued that many turloughs have formed in hollows in glacial drift and hence they should be regarded as glaciokarstic landforms. However, Coxon (1986, 1987a, 1987b) examined a large number of turloughs, including the 90 largest in Ireland all of which have a maximum area of

inundation in excess of 10 ha. She concluded that "... in all instances where the nature of the depression could be demonstrated, a bedrock hollow appeared to be present" and that "In a large number of turloughs, bedrock is exposed at several locations on the surrounding slopes, or was shown by augering to be near the surface, while augering in the depression indicated a considerable depth of unconsolidated sediments" (Coxon, 1986, p359). On this evidence, turloughs may be considered to be 'closed depressions of moderate dimensions' that are found in areas underlain by limestone and hence may be considered to be a type of doline. Some authors have alluded to a similarity with poljes, but Williams (1964) and Coxon (1986) both argue that turloughs and poljes have little in common beyond their periodic inundation, although the two authors differ in terms of which features the two landforms are considered to have, or not to have, in common.

In summary:

- poljes and turloughs are both periodically inundated;
- lacustrine sediments are deposited in both poljes and turloughs;
- the area of inundation in poljes is generally much larger than in turloughs; the size range for the 90 largest turloughs in Ireland is 10 - 650 ha, with a median of 30 ha (Coxon, 1987b);
- poljes are more clearly defined as landforms than turloughs, i.e. they have clearer topographic divides and there is a clear break of slope between the area of inundation and the sides of the polje, which are usually markedly steeper than those of turloughs;
- there appears to be a greater degree of tectonic influence on polje location than is the case with turloughs;
- turloughs are clearly associated with glaciation, whereas poljes are found in a wide range of climatic zones, including the tropics.

The formation of turloughs remains a matter for speculation. Three options were proposed by Coxon (1986). Firstly, turloughs may be hollows due to glacial erosion and deposition, and the associated groundwater flow lines may have developed post glacially. The location of the flow lines could have determined which glacial depressions became turloughs, or alternatively the development of the flow lines may have been linked with the filling and emptying of the turloughs. Secondly, the turloughs may be glacial hollows, lying along preglacial flow routes which survived glaciation but now have an inadequate capacity due to clogging with glacial

deposits. Thirdly, glaciation may not have completely destroyed surface karstic features, and turloughs may thus be preglacial hollows modified by glaciation, with associated preglacial flow routes. Further evidence, particularly concerning the amount of glacial erosion which has occurred on the western lowlands, and concerning the nature of the bedrock floor of the turloughs, is required before it can be determined which of these models is closest to the truth, or whether more than one is true, and turloughs are polygenetic.

Turloughs and tiankengs

Turloughs have been recognised as special landforms by ecologists and groundwater hydrologists, although the term has not been widely used by karst scientists because to date turloughs have only been identified in a small geographical area. Similarly, the term tiankeng is not widely known because the majority of tiankengs occur in China, although examples have recently been recognised in other karst areas (Waltham, this volume). There does not appear to be a specific 'turlough forming process', but turloughs appear to be polygenetic landforms that are strongly associated with dissolution, karstic drainage and underground flow routes, and in most cases with glaciation. Like turloughs, there does not appear to be a specific 'tiankeng forming process' but, as argued in other papers in this volume, they appear to be polygenetic, resulting from a combination of focussed underground drainage, dissolution, collapse, and geology, notably bed thickness and structure. Tiankengs may be distinguished from other collapse dolines by their size and morphology and turloughs may be distinguished from poljes by their size and morphology. The two landforms lie at opposite ends of the doline spectrum, but it is appropriate that both terms should become established in the lexicon of karst geomorphology.

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