Maps of Australian Caves and Karst

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Introduction

In 1996 I was approached by the Australian Map Circle to present a paper on maps of Australian caves at their Conference in Canberra.

It soon became evident that information on the subject was voluminous but scattered widely, and there was no compilation. I therefore selected just a few themes to illustrate the scope of the subject without any pretence of a comprehensive survey, especially beyond New South Wales. The paper elicited considerable interest as it raised issues not normally occurring to the audience of professional cartographers, map curators and collectors. It led directly to the National Library of Australia commencing a collection of cave maps.

The original paper was published in *The Globe*, No. 44, 1996, pages 41-44 and was intended to be expository rather than definitive and aimed at cartographers and curators rather than cavers. The paper is republished here in slightly amended form to increase accessibility to speleologists.

Historical Cave Maps

Caves occur in a host rock, usually but certainly not necessarily limestone. They form an integral part of an assemblage of landforms, characterised by solution processes and known as karst. It is thus common for modern cave maps also to relate to surface landforms as part of a karst map. Such maps now form an important contribution to the recording of our nation's heritage.

Although caves have been utilised by man for many thousands of years and were first recorded perhaps 3,000 years ago, the earliest extant cave map may be that published by Georg Agricola in Basel in 1546. It represents a set of branching tunnels called the Stufe di Nerone (Nero's Oven), excavated in volcanic tuff near Naples.

Australia's earliest known cave map was drawn in 1827 by Surveyor Henry Hellyer as a rough sketch in his notebook, and has only recently come to light in the archives of the University of Tasmania (Middleton 1990). A sea cave in quartzite, North Cave is at Rocky Cape on the north-west coast of Tasmania. Its archaeological significance was realised even then, and several excavations were made in subsequent years.

The earliest known published maps are those of John Henderson (1832). On furlough from Bengal, Henderson made an extensive, privately funded journey from Sydney to Bathurst and Wellington in the second half of 1830, later traversing unexplored country easterly to the Hunter Valley and thence to Sydney. In a discussion of his theories regarding the origin of the red earth and bones, he produced sketch plans (without a scale) of 'Boree Cave' (Tunnel Cave, Borenore, BN-25) and of 'Wellington Cave' (i.e. Mitchell Cave WE-5). His notes also include a diagrammatic cross-sectional sketch of the Arch and karst at Borenore.

Surveyor-General Major Thomas Mitchell had also visited Wellington in June 1830. Curiously neither Mitchell nor Henderson mention the other's visits to the caves at most a few days apart; intellectual rivalry was probably at work (Dunkley, in this volume). In his *Three Expeditions into the Interior of Eastern Australia*, Mitchell included maps of what he called 'Large Cave' and 'Breccia Cave' at Wellington, the former being the present Cathedral Cave which is shown to tourists, the latter now known as Mitchell Cave (WE-5). These journals were not published until 1838, whereas Henderson was in print by 1832, and in the meantime also a cross-sectional view of ‘Gudarigby Caverns’, near Yass, was produced by George Bennett in 1832 and published in 1834 (Bennett 1834). The latter is intermittently flooded by Burrinjuck Dam and is well-known to divers.

From this beginning, three distinct phases of interest in cave maps can be recognised. From 1830 to about 1900 leading naturalists and geologists visited caves and successfully encouraged official support for their study, mapping and reservation. In the second, low activity phase from 1900 until about 1950 there was little interest in caves from any part of the community, other than for tourism, although a few early maps have recently become known (see for example Cooper et al. 1998). From 1950 onwards there has been an awakening interest, pioneered by recreational speleologists whose maps have in turn been utilised by scientists and environmentalists. The dominant driving forces have thus been paleontology and cave tourism up to the early years of this century, and recreation, geomorphology and resource documentation in the last 50 years.

For most of the first period bone hunters and paleontologists studied many sites mainly in eastern New South Wales and the south-east of South Australia, their reports and the significance of the sites then lying dormant for as long as a century. In 1881 Charles Jenkins was employed to search for fossil bones, producing a map of Cave Flat Cave at the curious scale of 20 feet to 1 centimetre NSW Parliament, 1882). Late in the nineteenth century a new factor, tourism rather than science became the driving force, and then, as now, governments wanted to know what resources they had. In 1896 the remarkable Oliver Trickett was appointed Superintendent of Caves in New South Wales, a position he retained until in 1906 the caves were transferred from his employer, the Mines Department to the Tourism Department. Being a licensed surveyor, Trickett commenced a program of surveying tourist caves throughout the state, much of it undertaken in his spare time (Middleton 1991). He published superb maps, many in colour, in Annual Reports of the Mines Department and in his series of Guidebooks to the Jenolan, Wombeyan, Yarrangobilly, Abercrombie and Wellington Caves. He also constructed three dimensional models, most of which have disappeared although photographs exist. His model of the Imperial Cave is displayed in the visitors centre at Jenolan Caves. Trickett’s influence is seminal and a century later his maps continue to inspire speleologists and latter-day cave surveyors.

There are few records of cave exploration in the period between the two World Wars. Maps of Tuglow Cave were prepared separately by Glanfield et al. in Easter 1934 (Cooper et al. 1998) and by Harper & Salmon in September 1934, the latter being unrecorded for over 60 years, along with some Tuglow sketches by R.N. Bracewell dating from 1939 (Dunkley, in prep). Oliver Glanfield’s map of Colong Cave ca. 1935 was widely used for the following 50 years or more. Noske and Welch produced maps of Mammoth Cave, Jenolan in 1942 (Dunkley & Anderson 1972).

In 1946 Australia’s first speleological society was founded in Tasmania. From this point enthusiastic and often well-qualified amateurs have dominated the exploration, documentation and mapping of Australia’s caves. In 1956 the Australian Speleological Federation began coordinating this work. It has established standards for cave mapping relating to the accuracy of survey instruments and the recording of information in symbolic form on maps, and maintains a database on some 10,000 caves, for which there are maps of over 2,000.

In the 1950s and 1960s the task of cave surveying was immensely laborious and there had been no technological advances since Trickett’s day. Theodolites or miners dials of varying degrees of antiquity were utilised, survey reductions were performed manually using trigonometrical tables, and the maps were plotted by hand. Today, cheap and accurate light-weight, hand-held compasses are used, calculations and plotting are driven by computer, and GPS instruments enable cave entrances to be plotted accurately. Comprehensive inventories of cave and karst features are then compiled for land management authorities.

The magnitude of the task and its essentially amateur nature means that the results are scattered widely among 30 clubs and many individuals. However compilations of maps have been published for many areas e.g. Jenolan, Bungonia, Tuglow and Timor in New South Wales, Mt Etna, Chillagoe, Mitchell-Palmer and Broken River in Queensland, the south-east of South Australia, and the Nullarbor Plain, among others. The value of this collection is incalculable and severely underrated by many land managers and scientists. Amateur output is, of course, not captured by statistics of Gross National Product, but the notional cost of the map of cave systems of Gregory National Park in the Northern Territory has been conservatively estimated at about $300,000, including $100,000 in actual out-of-pocket expenses, over $170,000 in on-site labour and $30,000 in off-site processing and drawing. On this basis the notional production cost of cave map collections in Australia is of the order of maybe $20 million, even after discounting many of little likely significance to scientists, land managers and recreational interests.

The use of cave and karst maps

Cave and karst maps serve many purposes: recording history, inferring underground hydrology, a convenient means of recording scientific information, route finding and visitor interpretation. Graffiti on cave walls enables us to reconstruct exploration history and infer visitor usage in former times.

Some have been produced under the pressure of environmental disputes, and the very existence of cave maps was instrumental in promoting conservation objectives and refuting ill-informed criticism of development proposals. For example, exploration and mapping of caves in southern Tasmania established that drainage from a quarry into one cave led underground to another large cave in a World Heritage Property, thereby invoking the powers of the Commonwealth Government which eventually forced the quarry to close. In parts of South Australia and Florida, mapping of underground aquifers has established flow patterns of polluted groundwater.

Good maps of caves enable geologists to infer their mode of origin and a large literature exists, using cave maps to relate geological structure and solution processes to the development and present-day appearance of caves. Plans that reveal linear, anastomosing or network mazes each reflect differing dominant modes of cave origin and development. Cross-sections frequently highlight the existence of two or more phases in cavern development; Jenolan Caves for example may be developed on at least five levels corresponding to at least five periods of active development.

Caves are three-dimensional voids within a host rock and several techniques have developed to improve visualisation and perception. Conventionally, an attempt was made to display the cave as a spatial object by some form of orthographic projection, in plan, long-section and cross-section, corresponding to the three spatial dimensions at right angles.

An obvious limitation of this system is that only detail which is roughly parallel to the projection plane can be represented with little distortion in any one view. In any such view, one projection plane is favoured at the expense of the other two. The problem is that most cave maps are not simple spatial objects conveniently parallel to one plane. Most are twisted through at least two of three dimensions.

An isometric projection enables the 3-dimensional nature of the projected object to be revealed in a single view, but this is still feasible only if key passages are parallel to the reference axis. Such diagrams are excellent for overall visualisation of the cave but on the other hand it is difficult to depict detail of floor deposits which are frequently important to scientists as well as cavers.

Experiments have also been conducted using stereographic projections, a technique particularly suited to deep vertical caves such as those in Tasmania. Specialised computer programs enable the plot to be rotated to any desired orientation, and stereopairs may be obtained from two views about 5^0 apart. The same program will also project the diagram on to any or all of 3 planes intersecting at right angles, and from surface elevation data can construct a representation of the surface above.

So far most of these non-conventional projections have been used for recreational or general purposes of illustration. For specific purposes, however, diagrammatic maps often convey information more clearly (see, for example, Dunkley & Anderson 1972). Maps of underground hydrological networks are often simplified isometric projections. Examples include a representation of underground drainage in the Junee-Florentine region of Tasmania (Eberhard, 1994. p. 27).

Geographical Information Systems software offers new opportunities for integration of cave maps with other resource data to assist environmental management planning. Cave passages can be shown in relation to surface features and/or geological structure, and different levels of passage, for example, can be printed automatically, either selectively or in different colours. Some fine examples have recently been produced by Canberra Speleological Society of Bullita Cave, Northern Territory.

Ultimately, the worth of any given method of presenting cave maps or diagrams must be assessed by those who might use them. The problem is analogous to that presented by the question of how to represent the globe as a two-dimensional map. Constant scale and/or direction are sometimes sacrificed for a specific objective. It depends on what you wish to use it for – there is no single correct representation.

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