Deflector faults
Possible applications in engineering design

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Abstract: Speleological investigation of some cave systems in Slovenia revealed characteristic cave patterns, related to some larger faults, termed *deflector faults*. Strings of collapse dolines indicate that a *collector channel* has been formed along the fault, on its upstream side. This observation may help when designing various hydrogeological projects.

Key words: cave system arrangement, speleogenesis, deflector fault, collector channel

Introduction

Engineering investigations and speleological research seldom go hand in hand. Commonly the results are only compared in hindsight, which makes direct investigation of the karst rather frustrating. This paper sets out to demonstrate that in some cases basic speleological access may reveal data that can back up the design of subsequent, more technically oriented, research. The present study was undertaken in the core of the classical karst of Slovenia, and it is based as much on earlier speleological work as upon more recent investigations of the relationships between geological structures and particular surface and subsurface karst phenomena (see Šušteršič et al., 2001).

Starting ideas

Larger scale karst subsidence phenomena that characteristically involve an element of catastrophic development are referred to generically as *collapse dolines* (see Cramer, 1944, p.327). By reference to the example of Rakovska kukava, Šušteršič (1997) demonstrated that very large collapse dolines can evolve from relatively small cave chambers. Detailed study of the valley´s morphology revealed that its volume (1.35 Mm^3) and its present shape are predominantly due the simple settling down of tectonic crush within the shatter zone of a local strike-slip fault, plus slope processes. The explanation is that underground water finds such zones difficult to break through. Consequently, once such a route was opened, flow along it would persist, even if the passage were repeatedly obstructed by periodic collapse of tectonic crush. This process would continue until the water could no longer cope with the increasing input of collapse material. Such dolines are described as *active*. Then

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the river would have to find another breakthrough location, which would be similarly unstable. During an extended period of repeated doline formation and subsequent deactivation, a string of collapse dolines in different stages of decay would appear along the fault. An evident periodicity in collapse valley locations is explained by relatively regular spatial alternations of mechanical properties of larger fault zones (ČAR, 1981).

ORGANISATION OF THE KARLOVICE CAVE SYSTEM

The Karlovice system (Fig.1) is the main outlet cave of Cerkniško polje. There is some evidence that its early formation preceded the Quaternary strike-slip along the Idria Fault (ŠUŠTERŠIČ, 2000). Until the late Pleistocene the system stayed "dormant" and possibly completely choked. During Würm II it was reactivated, and, due to the input of the Cerkniščica's mechanical load, the previous phreatic cave pattern turned to epiphreatic (ŠUŠTERŠIČ ET AL., 2002).
The total length of explored passages is about 9 km and the overall impression is of a well-defined "horizontal" cave. Nearly perpendicular to the regional gradient, the string of master channels – though built up of segments oriented in various directions – extends for nearly 2 km parallel to and between 100 and 200 m from the longer straight segment of the field border. As well as the parallelism of the string with the field margin, GAMS (1965) also noticed that it collects the water sinking into numerous ponors all along the field border. Thus the idea of the *collector channel* was born.

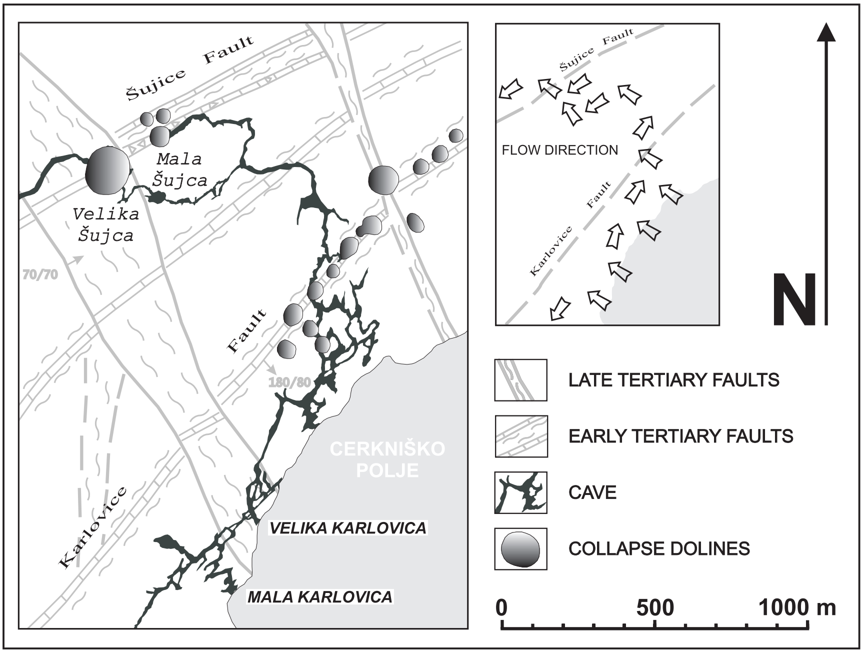

Figure 1.

In 1970 Gospodarič established that several minor faults guide the direction of particular structural segments within the cave. Čar and Gospodarič (1984) mapped the whole area between Cerkniško and Planinsko polje at a scale of 1:5000. Half a kilometre northwest from the polje border, they found an important cross-Dinaric fault with a wide tectonically deformed zone (*Karlovice Fault*). The parallelism of the fault with the polje border, as well as with the general trend of the *collector channel* is obvious (Fig. 1), and it implies that the fault exerted a great influence upon the formation of the cave maze.

A number of now-abandoned channels branch from the *collector channel*, heading towards the *Karlovice Fault*. Before reaching the fault zone most of them are blocked by collapse. Some collapses reached the surface, bringing about the formation of a string of collapse dolines, aligned exactly along the fault. The string actually extends beyond the known cave "influence area", indicating that the pattern also extends into the unexplored area. A collapse chamber marks the location of the actual breakthrough.

After having passed the fault zone the cave turns towards the west, until it encounters the collapses at the base of the Velika Šujca and Mala Šujca collapse valleys. Again, the wide fracture zone of an Early Tertiary fault (*Šujce Fault*, Fig.1), diverting the stream northwestwards, interrupts the direct route of the underground river. Here, the *collector channel* is less well expressed, as the input to the block between the two main faults is not so dispersed as before.

Discussion and conclusions

It becomes clear that minor faults can guide the development of cave channels. In contrast, the wide fracture zones of larger faults may have the opposite effect, and further development follows the pattern presented in the introductory paragraphs. A similar situation was recognised in part of the Postojnska Jama system (Gams, o.c.) and in Logarček (Šušteršič et al., 2001). In the latter case, the *deflector fault* runs nearly perpendicular to the polje border. The *collector channel*, though well expressed, is rather more distant from the fault, and more sinuous that in the two former cases.

Deflector faults delimit blocks with high internal karstic transmissivity, but they may also impede flow at the transitions between the blocks. Except in cases where the river has only just begun to flow the new way and collapses have not yet dammed it significantly, obstructions at the bases of the collapse dolines bring about noticeable differences of water table elevation on opposite sides of the faults. In the Karlovice system, the relatively recent transition across the *Karlovice Fault* is marked only by a collapse chamber, whereas a water table elevation difference of 5m was observed between the water levels on opposite sides of the Velika Šujica collapse doline / *Šujice Fault*.

Strings of generally inactive collapse dolines developed along well-marked fault lines prove them to be *deflector faults*. Studied *collector channels* have formed only a few hundred metres from the *deflector faults*, on their upstream sides, roughly parallel to the collapse doline strings. Among them, in any particular string, only one collapse doline is active, marking the present breakthrough position of the main underground water flow. However, in cases where the collapse has not yet reached the surface, the precise location of the breakthrough position is not yet recognisable.

Application of knowledge derived from these observations may benefit engineering project designs when prediction of transmissive cave channel locations are desirable, as for instance in searching for industrial water, grouting, or tunnel building. It is to be expected, however, that the highly transmissive *collector channels* will be heavily exposed to pollution and hence less appropriate as potential sources of drinking water.

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