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THE CAVES IN THE MOTORWAY DANE - FERNETIČI

JAME V TRASI AVTOCESTE DANE - FERNETIČI

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Tadej Slabe: Jame v trasi avtoceste Dane - Fernetiči

Pri gradnji avtocest na Krasu so bile odkrite številne stare jame in brezna. Stare jame, ki so votle ali pa zapolnjene z drobnozrnato naplavino ali gruščem, nam veliko povedo o zgodnjem razvoju tega dela vodonosnika. Kras je zelo prevotljen. Pri gradnji in uporabi avtoceste je treba zato preprečevati onesnaženje podtalnice, velika pa je tudi nevarnost vdiranja tal zaradi pogosto tankih stropov nad jamami.
Ključne besede: gradnja avtocest, Kras, Slovenija.

Abstract UDC 551.44:656.1(497.4)
Tadej Slabe: The caves in the motorway Dane - Fernetiči

During the construction of motorway over the (Classical) Karst several old caves and shafts were discovered. Old caves, that are either void or filled up by fine-grained sediments or rubble provide useful indication of early stages of of this part of the aquifer development. Kras is very cavernous. During the construction and use of the motorway, pollution of the groundwater must be prevented; an important danger presents subsidence-prone land due to thin ceilings above the caves.
Key words: motorway construction, Kras, Slovenia.

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INTRODUCTION

In Slovenia the motorways are planned to be located in Kras (the classical Karst). Karstologists take part in road planning, trying to avoid superficial karst phenomena such as larger dolines, collapse dolines and karst walls or other distinctive morphological features and caves. Due to the extremely cavernous aquifer with interconnected underground water courses and the importance of karst water resources, the new motorways are supposed to be impervious. Only treated waters should reach the karst surface. The karstologists also take part in road construction when numerous and diverse karst caves are being discovered. A part of the results I already presented at the Karstological School at Postojna (Slabe 1996). These are old caves, either void or filled up by fine-grained sediments and rubble, and shafts through which the water infiltrates from the permeable karst surface. Newly discovered caves provide a useful indication of the early stages of development of the central part of the Kras aquifer.

The waters from flysch Brkini Hills, Senožeče, Vipava and Pivka valleys and from gravel of the Soča valley are drained through the karst aquifer. Larger swallow-holes are located at the contact with flysch. Diffuse waters disappear from the permeable surface until they reach the underground flows which are now 300 m deep below the surface. Karstologists (Gams 1974, 197) consider that Kras attained its main relief properties when it was lower than Brkini and Vipava flysch. According to its superificial features and slops Melik (1960, 201) concluded that the former superficial drainage was over the dammed limestones and Radinja (1972, 13) came to the same conclusion from the sediments on the surface.

The motorway between Dane and Fernetiči cuts the karst ridge near Sežana and runs over the lowland towards the Italian border. Karst developed in Cretaceous limestones intersected by smaller faults that were the best seen during the tunnel digging. The karst surface is dotted by larger, mostly funnel-like dolines. Other parts, although covered by vegetation have a lack of soil. At the surface the longitudinal depression are filled up by loam. We assessed that these are old caves without roof already and filled up by fine-grained sediments.

THE CAVES IN THE MOTORWAY

The caves (72 newly discovered, Fig. 1) may be divided into old caves, remnants of former underground drainage, and shafts.

Cross-sections of newly discovered passages in old caves are from 1,5 to 8 m in diameter. They are mostly filled up by fine-grained sediments (16), only smaller caves (10) which by rule do not exceed 50 cubic meters of volume are void (Fig. 2). Speleothems in them are frequent, flowstone covering either

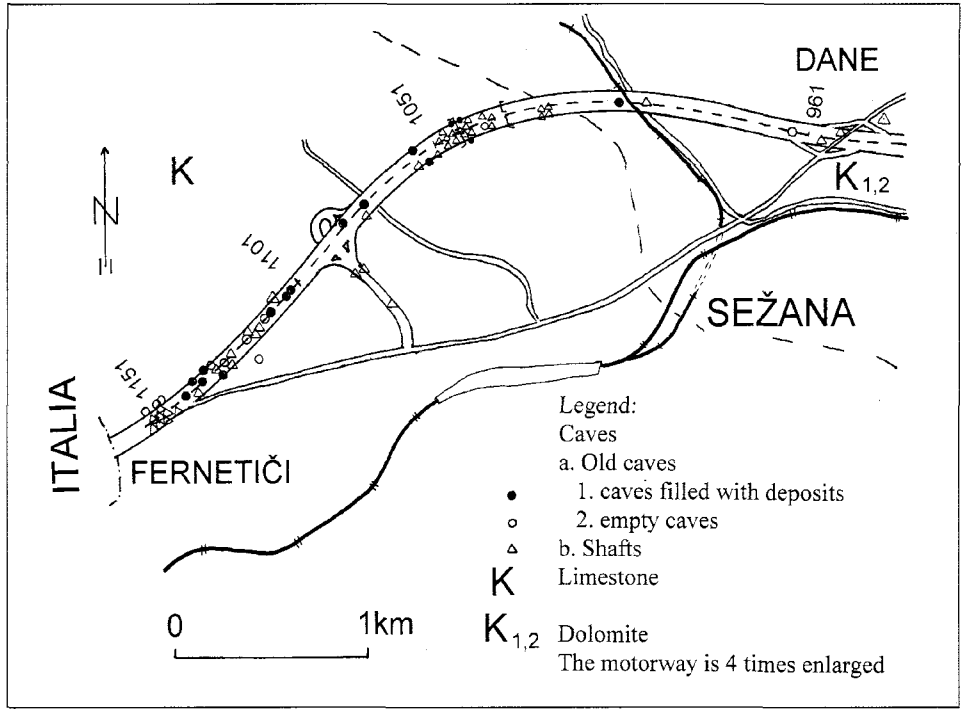
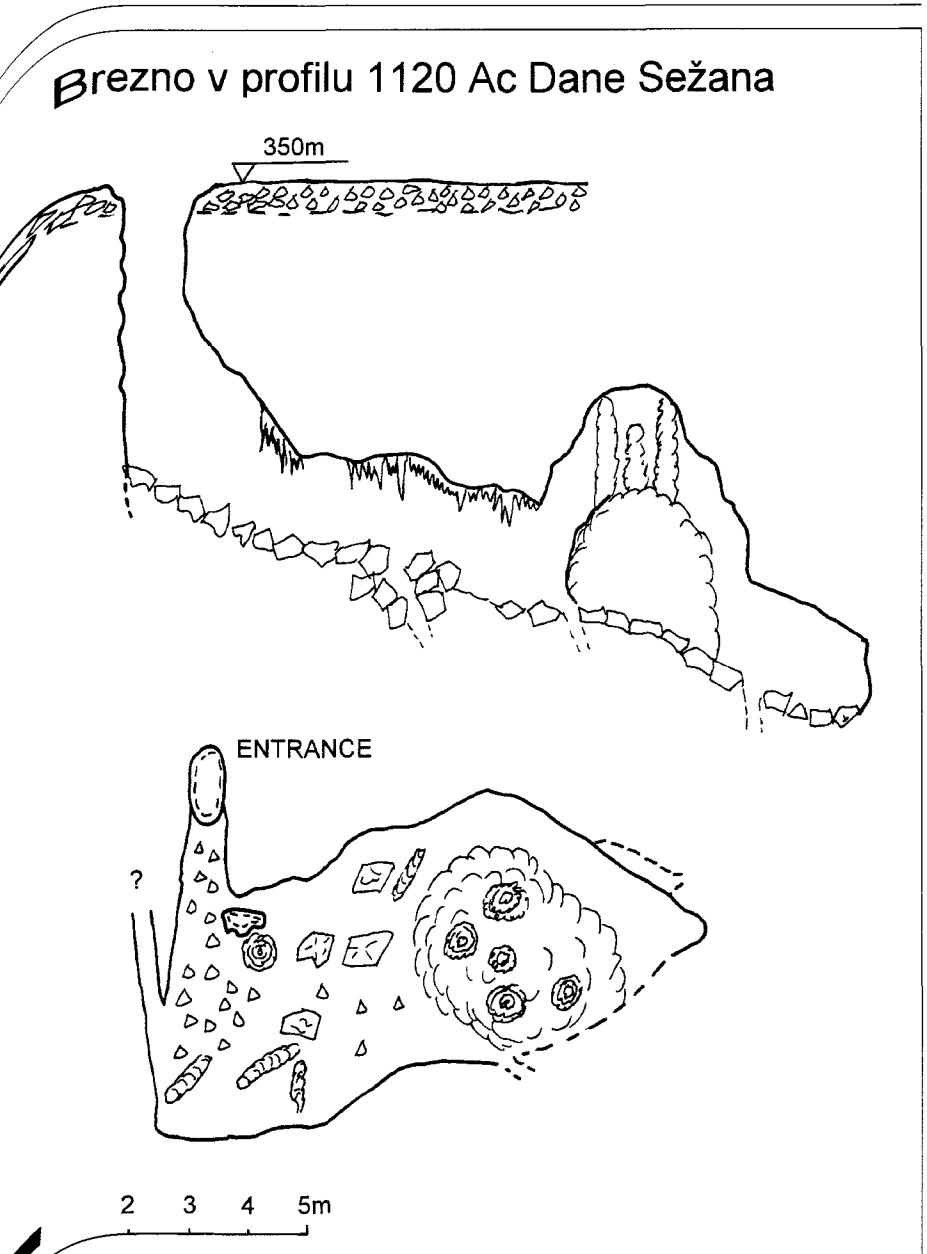


Fig. 1: Caves in the laying-out.
Sl. 1: Jame na trasi.

walls or floor. The ceilings above such caves are thin, from 1 to 2 m at the most. The network of pasages, their form and the rocky perimeters of these caves indicate that they were mostly controlled by slow water drainage in the phreatic zone.

Many old caves filled up by fine-grained sediments are already without roof (Fig. 3). The pasages wind like shallow indentations over the karst surface. They may be perceived even before the earthworks start. In road cuttings and tunnels the passages, filled up by fine-grained sediments, are seen in cross-section. The caves are filled up by layers of yellow loam and sand, frequently consolidated, and above them are ususally red loams and brown soil. The deposits cover the speleothems and calcite formations rarely is the deposit covered by flowstone. Relatively rare are traces of faster flows, such as small scallops; there were no pebble deposits found in these caves though they are frequent in old caves near Divača. The passages of old caves are frequently intersected by shafts and the sediments are there removed in a funnel shape. Old caves may be intersected by dolines also. A modest amount of water meandered in the bottom of some, usually smaller, passages (Fig. 4). The



Old cave.
Jama.

patches of flysch remained on some places on the surface for a longer time and water drained off them into the limestone.

Parts of newly discovered passages are filled up by coarse rubble (Fig. 5). Rubble, with sides mostly 5 cm in length, is due to weathering of the karst surface in one of the Pleistocene cold periods. Mostly it is found in parts of caves from where the fine-grained sediments were removed due to vertical permeability of the aquifer, and the thin roof collapsed just before the infill by rubble. In the passages the sections filled by loam and rubble alternate.

It seems that some newly discovered and relatively large old caves, either void or filled up by fine-grained sediments or rubble, in the western part of the motorway actually make part of a larger horizontal and vertical cave system that was unearthed during motorway construction over slightly undulating karst surface.

The water from the surface infiltrates underground by shafts and fissures. On the planned motorway two shafts were already known, the deeper one reaching 20 m deep. By denuding the surface during the earth works several other shafts (46) were discovered in relatively cavernous limestone, up to 110 m deep (Fig. 6). They may be divided into shafts with distinctive traces of percolation water, having ususally circular cross-sections and cracks of various dimensions that developed along the fissures, and with their walls often covered by flowstone; larger cracks developed along wrench-faults in fissured zones (Čar 1981). A lot of cracks are filled by flowstone, some of them widen in the shafts. Spacious, well decorated shafts make part of old cave systems that supposingly developed in a phreatic zone (cross-section 1122). Hollows, similar to shafts, developed among the breakdown boulders within disintegrated old caves. The most frequent were newly discovered shafts through which the water percolates into the aquifer. Most of them are located in the slopes or in the bottom of larger, funnel-shaped dolines. Most of shafts were without visible natural entrances. Narrow openings of difficult access appeared when the earth was removed. On the other hand spacious shafts were discovered and explored when digging the road cuts and tunnel, some 10 to 30 m below the surface. This is the consequence of water accumulation coming from a scattered infiltration through the permeable surface, which is being considerably lowered (Slabe 1996), and shafts are, also those with a natural entrance, collectors of this water. Klimchouk (1995) also assessed the diffuse water percolation into epikarst and converging of this water at the contact with vadose zone.

THE INFLUENCE OF THE MOTORWAY CONSTRUCTION ON CAVES

The deepest known shaft remained untouched at the border of the tunnel. By revealing the karst surface numerous smaller entrances into shafts appeared. Most of them were in the bottom of dolines. The workers blocked them

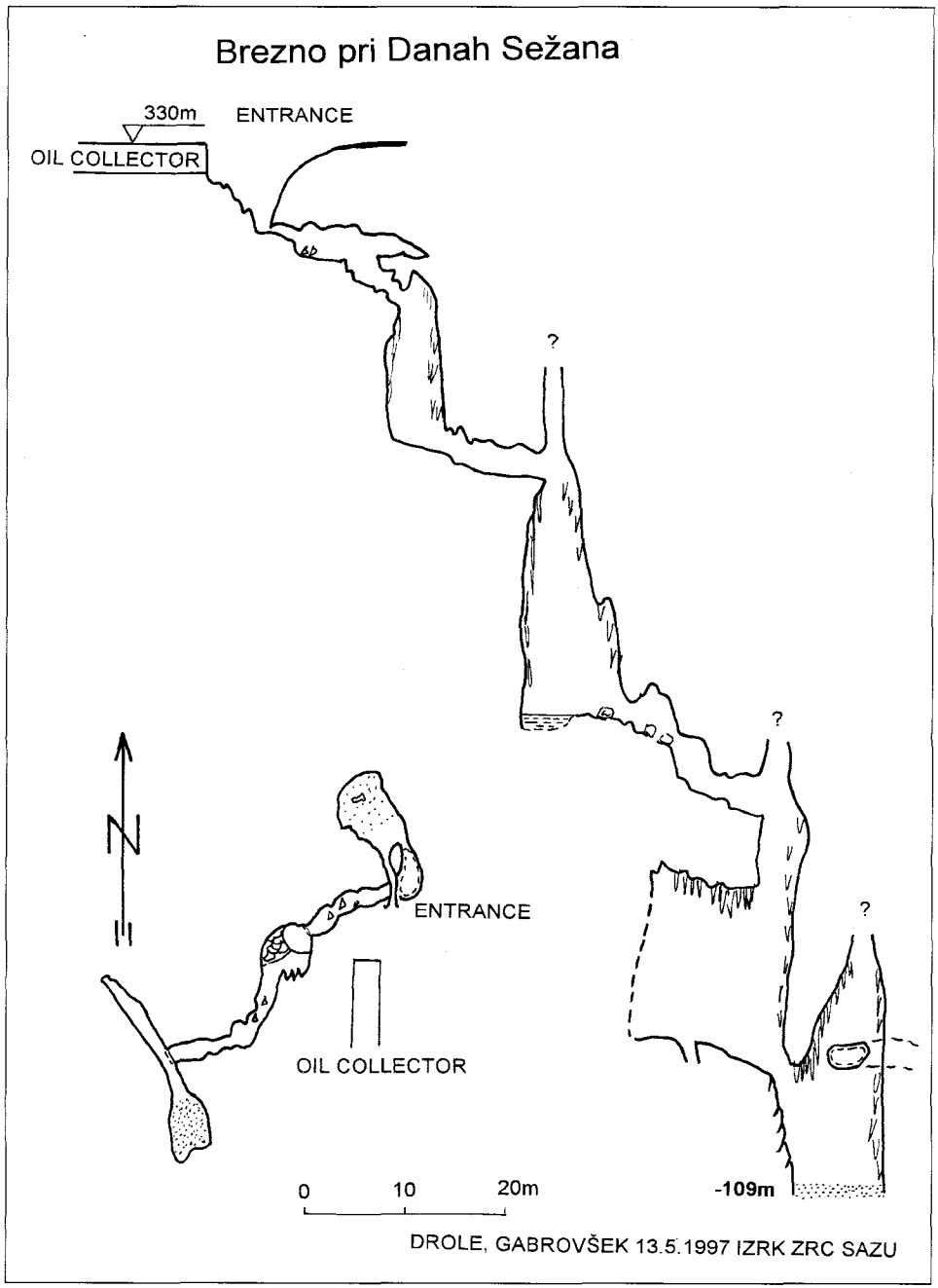


Fig. 6: Shaft.
Sl. 6: Brezno.

by large rocks cemented by a concrete. Dolines were later filled up by layers of stones and rubble and consolidated by a vibration roller. Also the fine-grained deposits and rubble were removed from the old caves and they were filled up by rocks and concrete.

Larger shafts frequently opened in roadcutings. The exploration was a demanding task as the perimeters of the entrance parts were very crushed and the rocks unstable due to blasting. Smaller shafts below the laying-out were filled up by rocks and consolidated by concrete. One of bigger shafts was unaccessible (cross-section 1048) because larger rocks collapsed in it. During the earth works the shaft was filled up. We suggested consolidating the area above it by strong concrete.

Fine-grained sediments from old caves located in the sides of road-cuts were washed to the roadway. The caves were sealed by walls.

During the digging of a tunnel several old caves and shafts opened. As they were of smaller dimensions they were closed by the concrete arch of the tunnel. The caves in the ceiling of the tunnel were unaccessible. The rocks of their perimeter were crushed due to blasting, rocks and rubble poured out and the perimeter was disintegrating.

CONCLUSION

A large share of the surface of this part of the Kras aquifer is occupied by old caves, filled up by fine-grained sediments and rubble and already unroofed. The upper parts of the aquifer have been affected by infiltration water for a long time. Mostly large old caves evidence the time when the ground water was close below the actual surface. Supposedly close to them a flysch nappe remained and from it smaller superficial waters drained. The ponor properties of some caves indicate the same. Their bottoms are meandering and deepened by smaller water flows. Flysch remained over the limestone long after the lowering of the underground water table, yet the water reached the caves during high waters and finally filled them with fine-grained sediments. During cooler periods of the Pleistocene some of old caves were filled up by rubble. The great cavernosity of this part of Kras is evidenced by the numerous shafts and fissures that were discovered during the earth works. Also in this part of the karst there were no traces of superficial water flows that could belong to the time when the limestone was still dammed. The same was noted on the section of the motorway between Čebulovica and Dane. All the discovered sediments are of cave origin.

Great cavernosity is one of the most reliable indicators of permeability, warning us again how carefully the rodas must be constructed and later used. The roadway should be impermeable in order to assure that only treated waters drain off it each day, and the road surface should be protected against

accidental spills of harmful substances. When the rubble on the roadway had been consolidated by a vibration roller some sinkholes appeared. The roof above smaller caves collapsed. Considering this great cavernosity, there exists the possibility that some larger cave is hidden underneath. This it means that the georadar survey is very important for safety of the roads.

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JAME V TRASI AVTOCESTE DANE - FERNETIČI

Povzetek

Na slovenskem krasu se hitro gradijo avtoceste. Krasoslovci sodelujemo pri načrtovanju avtocest, ko se izogibamo površinskim kraškim pojavom kot so večje vrtače, udornice in kraške stene ter značilno oblikovane večje skalne površine, in večjim jamam. Sodelujemo tudi pri gradnji avtocest, ko se odkrivajo številne in raznolike kraške jame. Del sem jih že predstavil (Slabe 1996). To so stare jame, ki so votle ali pa zapolnjene z drobnozrnato naplavino in gruščem, ter brezna, skozi katera prenika voda s prepustnega kraškega površja. Novoodkrite jame nam veliko povedo o razvoju osrednjega dela vodonosnika Krasa.

Skozi kraški vodonosnik se pretakajo vode s flišnih Brkinov, Senožeške, Vipavske doline in Pivške kotline ter iz proda Soške doline. Na stiku s flišem so večje ponorne jame. S prepusnega površja vode razpršeno prenikajo do podzemeljskih voda, ki so danes več kot 300 m globoko pod površjem. Krasoslovci (Gams 1974, 197) menijo, da je kras dobil glavne reliefne značilnosti, ko je bil nižje od brkinskega in vipavskega fliša. O sledeh prvotnega površinskega odtoka po zajezenih apnencih sklepa Melik (1960, 201) po obliki površja in njegovih strmcih, Radinja (1972, 13) pa po naplavinah na površju.

Trasa med Danami in Fernetiči predre kraški hrbet pri Sežani in nato poteka po ravniku do italijanske meje. Kras se je oblikoval v krednih apnencih, presekanimi z manjšimi prelomi, ki so najlepše razvidni pri kopanju predora. V kraški ravnik se zajedajo večinoma večje, lijakaste vrtače. Tudi na ostalem, večinoma poraslem površju je le malo zemlje. Površje prepredajo tudi večje zajede, v katerih je ilovica. Ugotovili smo, da so to stare jame, ki so že brez stropa in zapolnjene z drobnozrnato naplavino.

Presenetljivo velik delež površja tega dela vodonosnika Krasa zavzemajo stare jame, ki so zapolnjene z drobnozrnato naplavino in gruščem in so že brez stropov. Zgornji deli vodonosnika so že dolgotrajno preoblikovani s prenikajočo vodo. Stare jame so torej sledi časa, ko je bila podzemeljska voda še tik pod današnjim površjem. To je seveda zaradi stalnega nižanja kraških predelov nižje od prvotnega. Velikost rovov priča, da so se skozi njih pretakali večji vodni tokovi, ki so rove sprva povsem zalivali. V bližini pa je bil verjetno tudi ostanek flišnega pokrova, s katerega so se stekale manjše površinske vode. Na to kažejo ponorne značilnosti nekaterih jam. Njihova dna so namreč vijugasto poglobljena z manjšimi vodnimi tokovi. Fliš se je na apnencu ohranil še dlje časa po znižanju gladine podzemeljske vode, ki pa je jame ob izjemnih poplavah še dosegala in končno celo zapolnila z drobnozrnato naplavino. Del starih jam je bil v hladnejših obdobjih pleistocena zapolnjen z gruščem. Veliko prevotljenost tega dela krasa dokazujejo tudi številna brezna in špranje, ki so bila odkrita pri zemeljskih delih. Tudi v tem delu krasa ni bilo najti sledi površinskih vodnih tokov iz časa, ko je bil apnenec še zajezen. To smo ugotovili tudi na trasi med Čebulovico in Danami. Vse odkrite naplavine so jamske.

Velika prevotljenost eden izmed najbolj zanesljivih kazalcev prepustnosti, kar nas še enkrat opozarja na izredno pazljivost pri gradnji ceste in nato pri njeni uporabi. Cestišče bi moralo biti neprepustno, tako da bi se z njega resnično stekale le prečiščene vsakodnevne vode, površje pa bi moralo biti zavarovano tudi pred morebitnimi nesrečnimi razlitji škodljih snovi. Tudi pri utrjevanju grušča na cestišču s tresočim valjarjem so nastajali grezi. Udrli so se stropovi nad manjšimi jamami. Ob veliki prevotljenosti pa bi bila lahko tik pod površjem še kakšna, tudi večja jama. Pregled takšnih tras z georadarjem je torej zelo pomemben za varnost cest.

Fig. 3: Roofless cave.
Sl. 3: Jama brez stropa.

Fig. 4: Old swallow-cave without roof.
Sl. 4: Stara ponorna jama brez stropa.

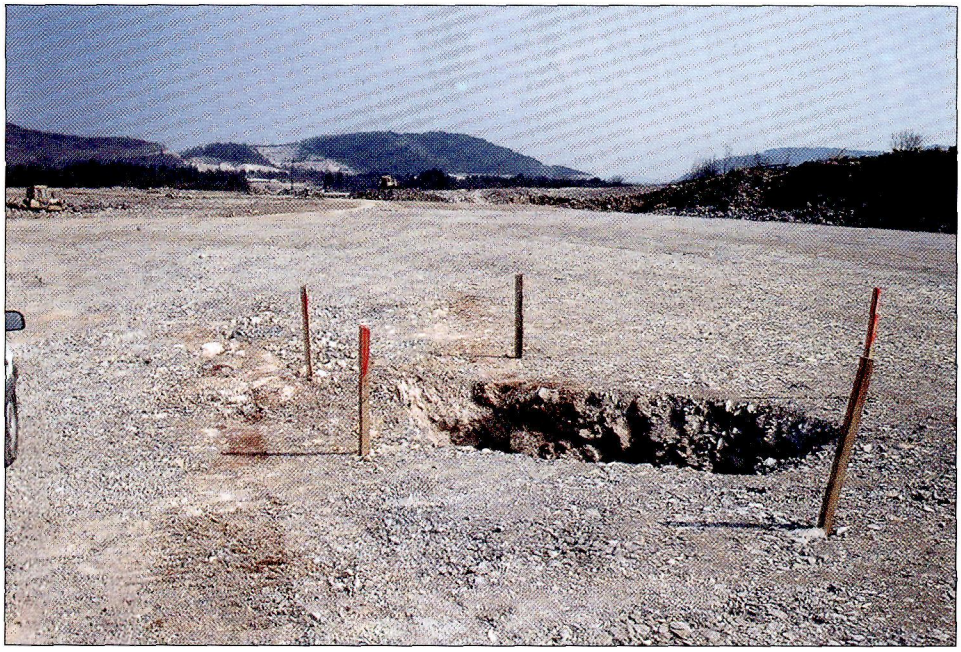

Fig. 7: Collapse can occur even when the earth-works are finished.
Sl. 7: Do udora lahko pride tudi po zaključku zemeljskih del.

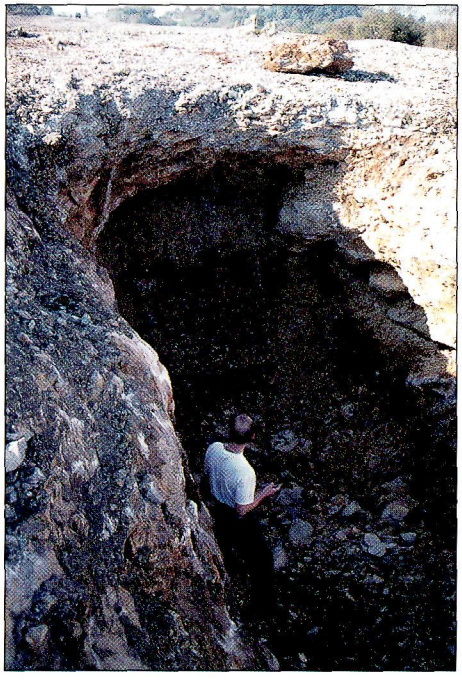

Fig. 5: Cave filled up by rubble.
Sl. 5: Jama zapolnjena z gruščem.