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THE NATURE AND GENESIS OF SOLUTION CAVITIES (MAKONDOS) IN TRANSVAAL CAVE BRECCIAS

by

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INTRODUCTION

The discovery of a large part of the cranium of a hominid, evidently closely related to *Homo habilis* (Hughes and Tobias 1977) in a solution cavity within the calcified Member 5 of the Sterkfontein Formation (Partridge 1978) has again drawn attention to the frequent occurrence of these features in the hominid-bearing breccias of the Transvaal. The authors first studied these features at Makapansgat (fig. 1) some fifteen years ago and have since then become aware of their very widespread occurrence in soluble rocks in many parts of the world. All subsequent information has served to confirm the origin of these features, but, since these were never published, it is worthwhile to place these findings on record.

Solution cavities, or Makondos,* in the Transvaal cave breccias are soil-filled pits shaped like an inverted cone. Their walls and intervening areas of the calcified cave deposit are usually rough, and the coalescing of adjacent cavities below the surface is common. They seldom exceed 2 m in diameter and 6 m in depth and occur at intervals of 2 to 3 m in the calcified cave deposit.

OCCURRENCE

Similar features have been observed by the authors in calcified alluvial deposits of the Vaal River (Partridge and Brink 1967), calcareous gravels at Long Hanborough near Oxford, England (fig. 2) and in coastal calcarenites; counterparts have been reported from Florida, California and Brazil and are doubtless common in many other areas (*Geotimes* July 1973). They are invariably associated with areas in which soluble rocks are present beneath a mantle of superficial soil.

MODE OF ORIGIN

These pits contain a surface transported soil which overlies residual material from the adjacent host-rock. It is clear, therefore, that they are formed by corrosion and decalcification rather than by the mechanical action of water or wind.

*The name Makondo has previously been suggested (Partridge and Brink 1967) for this type of corrosion pit in recognition of the valuable services rendered by the late William Makondo in investigations at the Makapansgat Limeworks hominid site.

Figure 1. Makondo in Member 4 of the Makapansgat Formation.

As a possible explanation of the mechanism of corrosion, it is suggested that deep-rooting vegetation will tend to take root in joints in the host-rock and would subsequently provide concentrations of organic acids which would cause local decalcification of the surrounding deposit. Successive generations of vegetation would tend to continue to take root in the pits and to extend them downwards.

PIT FILLINGS

Since the carbonate content of Transvaal cave breccias usually exceeds 40 per cent, this process produces a soil residue of insoluble substances in

Figure 2. Makondos in calcareous gravels at Long Hanborough, near Oxford, England.

the bottom of the pit which is of substantially smaller volume than that of the original calcareous material. This leads to a continual infilling and admixture of transported material from the surface as the pit is extended in depth and diameter.

The residual materials are somewhat better sorted and less angular than the sediments of the host material, have a smaller mean particle size and display almost ubiquitous pyrolusite (MnO_2) skins on individual sand grains and bone fragments. Pyrolusite skins are relatively uncommon in the more highly calcified cave deposits in which ferric coatings tend to predominate. However, pyrolusite staining is extremely common in the shallow dolomitic soils which are forming today in the vicinity of the Transvaal cave deposits.

These observations can be explained by the fact that silica grains which form the bulk of the residual pit-fillings are subject to slow corrosion by percolating water; the rate of solution increases with an increase in the pH of the water. This process leads to a reduction in angularity and size of quartz particles. The sorting may be further improved by the illuviation of fines from overlying accumulations of fine-grained transported colluvium.

The black skins which develop on the constituent particles of dolomitic soils originate from manganese entrapped within the crystal lattice of the dolomite bedrock (Truswell and Eriksson 1975). The australopithecine-bearing cave deposits at Makapansgat, Sterkfontein, Swartkrans and Kromdraai all occur within that stratigraphic zone of the dolomitic Malmani Subgroup known as the Monte Christo Formation. In this stratigraphic unit the dolomite has a very consistent MnO content of 0,3 per cent (Truswell and Eriksson 1975) which is released on solution of the dolomite to form pyrolusite in the soil; evaporation often tends to concentrate the pyrolusite near the soil surface. This soil formed the source materials for the major part of the various cave deposits. With it were introduced the various faunal and hominid remains as well as a varying proportion of intra-cavernous debris. Drip of calcium bicarbonate-bearing water from the cave roof cemented these deposits into a cave breccia with a carbonate matrix mainly in the form of calcite (Brain 1958). Apparently the pyrolusite coatings around the sand grains were incorporated within the calcite lattice when calcification occurred relatively rapidly and effectively. Truswell and Eriksson (1975) have observed that manganese is considerably more miscible in calcium carbonate than is iron which may explain this phenomenon and also that of the almost exclusive presence of reddish brown ferric skins in the more highly calcified parts of the deposits. On decalcification within the Makondos the manganese entrapped in the calcite material is again released to produce pyrolusite coatings which impart the characteristically dark colouring to these unconsolidated fillings and the black staining to the bones. In some cases molecular replacement with pyrolusite occurs within the bones, resulting in a more resistant fabric. Certain stratigraphic units within the various cave deposits which are characterised by such dark colouration and staining have undergone relatively ineffective calcification, or they may have been decalcified since the carbonate cement was originally introduced, for example Member 2 at Makapansgat and Member 6 at Sterkfontein.

HOMINID REMAINS STW 53

The cranial remains from Sterkfontein (Stw 53) referred to earlier exemplify the above observations. A large part of the cranium and associated mandibular ramus were found in the unconsolidated filling of a Makondo within Member 5 of the Sterkfontein Formation at a depth of between 2,44 and 2,74 m below surface. The remaining calvarial fragment of the cranium was embedded in the calcified breccia forming the wall of the pit at a somewhat higher elevation of 2,34 to 2,44 m. That part of the fossil which was retained in the cemented cave deposit was largely unstained while those fragments recovered from the residual soil within the pit were blackened and partly replaced with pyrolusite.

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