MINERALOGICAL MAGAZINE, MARCH 1977, VOL. 41, PP. 33–5

# Archerite, $(K,NH_4)H_2PO_4$, a new mineral from Madura, Western Australia

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SUMMARY. Archerite, $(K, NH_4)H_2PO_4$, a new mineral, has been found in Petrogale Cave, 36 km east of Madura Motel (31°54'S, 127°00'E) Western Australia. Archerite and biphosphammite together with aphthitalite, halite, syngenite, stercorite, oxammite, weddellite, whitlockite, guanine, newberyite, calcite, $(NH_4)_2Ca(HPO_4)_2 \cdot H_2O$, and an unknown occur as stalactites and wall and floor crusts.

Archerite is tetragonal with second order prisms and pyramids in crystals up to 2 mm in length with *D* 2·23, $\omega$ 1·513, $\epsilon$ 1·470, all close to artificial $KH_2PO_4$. The mineral is soft, has a white streak, and is soluble in cold $H_2O$. Cell dimensions of natural archerite were not determined and the composition was calculated from measurements of selected powder lines correlated with charts prepared from end-member data and by chemistry which gave 81% $KH_2PO_4$ and $K_2O$ 10·8, $NH_3$ 3·46 respectively, the latter corresponding to $(K_{0\cdot74}(NH_4)_{0\cdot26})H_2PO_4$.

The name is for Dr. M. Archer, Curator of Mammals, Queensland Museum. Type material is stored in the collections of the Government Chemical Laboratories, Perth, Western Australia.

THE discovery in February 1975 of natural $KH_2PO_4$ confirmed the existence of a mineral that had been proposed on the basis of analyses in Pryce (1972). An active search of the caves of the Nullarbor Plain by the author and friends for guano deposits that might contain the mineral led to Petrogale Cave. Previously the mineral had been found in Murra-el-elevyn Cave with biphosphammite, Bridge (1973). However, the small amount available and unsuitable data made the discovery of new material necessary.

In 1969 M. Archer and B. Muir on a W.A. Museum expedition found a new cave and collected mineral samples, including a biphosphammite stalactite. The cave, Petrogale Cave, is situated on the edge of the scarp, 36 km east of the old Madura Motel (31°54' S., 127°00' E), 1060 km east of Perth, Western Australia.

It was not until April 1973 that the author and his wife with K. Williamson and V. Ryland of the W.A. Speleological Group were able to visit Petrogale Cave. The success of the collecting was somewhat marred by the destruction of the Landrover in a roll-over on the return trip and unfortunate damage of some of the more delicate mineral crusts.

*Occurrence*. The cave is entered through a small sinkhole, which opens into the entrance chamber containing old calcite decoration. The main guano deposits are at the far end of the cave, reached through several long chambers and tight clefts. Dry pulverulent guano covers the cave floor except in the end chambers where convoluted crusts of aphthitalite and other minerals also occur. These appear to have formed from the desiccation of sludge-like guano deposits. The walls are coated with dark crystalline crusts, in places forming stalactites up to 12" in length. These are mainly composed of biphosphammite.

Only a few dozen bats were observed, though the cave may be the site of a maternity colony and have considerable seasonal variation in population. Skeletal remains from the walls and floor were identified as *Chalinolobus morio*, Gray, the same bat that appears to have produced the Murra-el-elevyn Cave guano deposits.

There is no evidence that the floor crusts are being added to at present. All fresh guano is devoured by coprophagic insects, which produce the guano dust. The crusts appear to have originated at a time when the bat population was very large. The stalactites form roosting places for the bats and there is little doubt that these could still be growing from the crystallization of urinary deposits from the bats, even in their present small numbers.

The activity of the cave insects was observed by Archer and Muir (unpublished field notes) and they point out that the work of insects in obliterating surface features and in shifting cave sediments should not be underestimated.

The temperature and humidity of the rear chambers of the cave were respectively 20·5 °C and 68·5 %.

Minerals associated with the biphosphammite and archerite are: aphthitalite, halite, syngenite, stercorite, oxammite, weddellite, *unknown A*, whitlockite, guanine, newberyite, $(NH_4)_2Ca(HPO_4)_2.H_2O$, and calcite from the wall rock. The stalactites are mainly composed of biphosphammite with varying amounts of other minerals except the guanine and $(NH_4)_2Ca(HPO_4)_2.H_2O$. Most of the associated minerals occur around the upper portions of the stalactites where they join the wall or ceiling. The elongated portion of the stalactites is nearly all biphosphammite. Some stalactites of aphthitalite occur.

Archerite occurs on only a few samples in the form of small tetragonal crystals up to 2 mm in length and crusts of a buff to clear colour. The specimens containing archerite are stalactites, with minor amounts occurring in the convoluted wall crusts, which are mainly aphthitalite with the other minerals listed above.

Small crystals of $(NH_4)_2Ca(HPO_4)_2.H_2O$ occurred in several samples of crusts associated with biphosphammite, aphthitalite, and guanine. The artificial compound has been described by Frazier, Lehr, and Smith (1964). The X-ray powder pattern of this mineral is similar to P.D.F. card 20–203.

Another unidentified mineral (unknown A) is insoluble in water and the eight strongest X-ray diffraction lines are 6·17(10), 5·57(8), 2·91(6), 3·82(5), 2·32(5B), 3·71(4), 3·42(4), 2·42(4). These lines were measured on 11·4 cm diameter camera film without an internal standard. Preliminary electron micro-probe examination shows major P, K, Ca, Mg and minor Cl.

Data on these two incompletely described minerals is included in advance of a full description, which may not be possible for some time.

*Physical properties.* Archerite is tetragonal with second order prisms and pyramids. The $D$ of natural archerite calculated from the cell-dimension charts on material of 81 % $KH_2PO_4$ is 2·23 and of $KH_2PO_4$ is 2·34 (Winchell and Winchell, 1964). There is no distinct cleavage and the mineral is relatively soft with a white streak and is water-soluble.

Archerite is uniaxial negative with $\omega$ 1·513, $\epsilon$ 1·470, close to pure $KH_2PO_4$, $\omega$ 1·510, $\epsilon$ 1·468, Pryce (1972). These measured values correlate well with those of archerite of 81 % $KH_2PO_4$ calculated from charts prepared from the values of the pure end members.

*Chemistry.* An analysis of biphosphammite containing isomorphous archerite from Murra-el-elevyn Cave is reported in Pryce (1972). Partial analysis of archerite from Petrogale Cave by R. Schulz and R. J. Everett gave $K_2O$ 10·8, $NH_3$ 3·46, corresponding to $(K_{0\cdot74},(NH_4)_{0\cdot26})H_2PO_4$.

*X-ray data.* The X-ray powder data for archerite are similar to those of artificial $KH_2PO_4$. Measurements of the 202, 303, and 404 lines on 11·4 cm powder patterns with $ThO_2$ internal standards were correlated with charts calculated from the data of the pure end members $KH_2PO_4$ and $NH_4H_2PO_4$ giving 81 % $KH_2PO_4$ and 19 % $NH_4H_2PO_4$. The unit cell of artificial $KH_2PO_4$ was calculated as $a$ 7·448 Å, $c$ 6·977 Å by Swanson and Fuyat (1953) and $a$ 7·451±0·001 Å, $c$ 6·972±0·0015 Å by Pryce (1972); space group $I\bar{4}2d$, $Z = 4$. The unit cell constants were not determined for natural archerite.

Type material is stored in the collections of the Mineral Division, Government Chemical Laboratories, Perth, Western Australia.

The name is for Dr. Michael Archer, friend and Curator of Mammals, Queensland Museum, who first drew the author's attention to the deposit.

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[*Manuscript received 19 May 1976*]