

## **‘Malachite, Azurite, Chrysocolla and their Pseudomorphs’ by Jim Sharpe**

As an introduction to his talk Jim Sharpe displayed a slide of what is said to be the best azurite specimen in the world which currently resides in the American Museum of Natural History in Washington D.C. It is a group with crystals up to 150mm in length and had something of a history. It was found by an African miner in the Tsumeb mine in 1952 who had to smuggle it out of the mine since the management of Tsumeb never officially allowed specimen collecting by the miners. The miner was apparently something of a heavy drinker and effectively traded the specimen to one of the publicans in Tsumeb to help pay off his bar tab. Unfortunately for the publican the mine manager heard about the acquisition and went to see the publican advising that the specimen was mine property, it had been stolen, and demanded it be handed over.

The specimen was then sent to New York and resided for a while in the offices of the Newmont Mining Company, one of the parent companies owning Tsumeb, until the early 1970s when it was presented to the Museum of Natural History. The speaker was able to see this specimen for himself when visiting the Museum in the 1980s. It was displayed in a cabinet all to itself sitting in the middle of the floor of the Mineral Gallery with a label proclaiming it not only to be the best azurite specimen in the world but also simply the best mineral specimen in the world. This is presumably something that could be debated by collectors but in 1977 it was valued at US\$250,000. This was obviously a very considerable increase to whatever the African miner would have been paid !.

Azurite and malachite are basic copper carbonates both containing hydroxyl ions, chrysocolla is a copper silicate. Azurite is readily found as crystals, sometimes quite large whereas malachite may only be found rarely as small fine needle crystals in cavities but much more commonly as large botryoidal masses infilling fractures and vughs in rock. The largest crystals of malachite personally collected by Jim Sharpe were found during a field trip when in company with Peter Williams he visited a small deposit called the Canteen Mine some 40 to 50 klm from Cloncurry. One rock upon being broken open revealed a small vugh with malachite crystals a little over a centimeter in length. Since the rock had been split apart to find the crystals and both halves were mineralised this gave the two collectors one specimen each. Unfortunately in spite of searching the site thoroughly and presumably breaking open quite a few more rocks no more malachite crystals were found. Whilst the speaker was not certain what were the largest crystals of malachite in existence he thought that specimens from Bisbee had crystals about three times larger than those he had found.

In noting that much more malachite is found in deposits than azurite Jim Sharpe referred to the chemistry of the two very similar minerals, azurite  $\text{Cu}_3(\text{CO}_3)_2(\text{OH})_2$  and malachite  $\text{Cu}_2(\text{CO}_3)(\text{OH})_2$ . Azurite is seldom found at the surface of a deposit whereas malachite may be plentiful. Also it was noted that weathering of bronze statuary around the world always produces a green patina, never a blue. Obviously the oxygen,  $\text{CO}_2$  and water content of the atmosphere favoured the production of only malachite in surface deposits and on statuary. By reference to images of a number of specimens and to charts the speaker described the chemical basis for the respective formation of copper carbonates which depended on the prevailing partial

pressure of CO<sub>2</sub> in the environment where a copper carbonate mineral was forming. Malachite will form in an environment containing 0.32kpa of CO<sub>2</sub> which is the normal level in atmosphere whereas the formation of azurite requires an environment containing a minimum of 4.34kpa CO<sub>2</sub>. At depth in fault-hosted systems in fractured rocks where metal sulphides have been injected subsequent establishment of an oxidation zone will generate sulphuric acid. This would then react with carbonate minerals that might be in the vicinity such as calcite or limestone generating CO<sub>2</sub> which would then form copper carbonates.

This process favoured the formation of malachite pseudomorphs after azurite whereas the alternate situation of the formation of azurite pseudomorphs after malachite is extremely rare and Jim Sharpe has never seen one although he has heard that some do exist. Some of the best pseudomorphs in the world came from Tsumeb and the speaker showed a number of images of specimens. The best localities for malachite pseudomorphs in this country have been the Sir Dominic Mine in South Australia and the Whim Creek Mine in Western Australia, the latter deposit having also produced specimens of chrysocolla pseudomorphs after azurite. By reference to X-ray diffraction analyses of specimens and mineral stability and solubility charts the speaker explained that chrysocolla can only form pseudomorphs after azurite if specimens first pass through a malachite stage. Malachite and azurite can also pseudomorph after other minerals such as calcite and the speaker showed examples of specimens from the Red Dome Mine near Chillagoe. Jim Sharpe suspected that some specimens he had examined might be examples of a quadruple pseudomorph system where calcite had been replaced by azurite which was then replaced by malachite which then was being replaced by chrysocolla.

The final image showed by the speaker was of a magnificent 'copper sunset' which he had captured on one of his many trips to the Cloncurry area.