

A visit to the Kalkkop Crater

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An hour's drive due south of Graaff-Reinet, on a dirt road, lies the Kalkkop Crater. About 250 000 years ago, a meteorite, estimated at about 20m wide, hit the unsuspecting Karoo. It left a 90m-deep bowl-shaped crater rather like the famous Meteor Crater of Arizona or Tswaing north of Pretoria, but only about half as big. Soon a shallow lake of brackish water formed inside it. As it evaporated, limestone was left behind. Gradually layer upon layer of white limestone was deposited, until the crater was full. Some time between then and now the Karoo became drier and the crater with its limestone fill began to erode away.

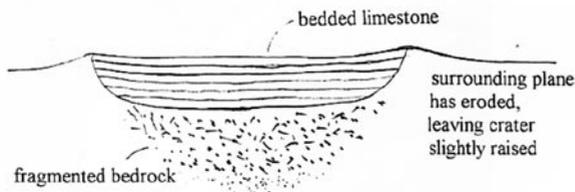
In 1999 a group of Gauteng businessmen heard about the crater and asked a Graaff-Reinet tour company to organise a dinner for them right in the middle of it. They wanted a New Year all-night formal sit-down dinner there. They called it "Y2KKK" (Y2K in the Kalkkop Krater). Long before the time the tour company asked me to write a night-sky pamphlet for the event, including

star maps and information about comets and meteorites, emphasizing the impact that the heavens can have on the Earth. The year 2000 dawned and the dinner was successfully served (the hosts remember it now as a logistical nightmare).

The Dawn of the Year 2000 celebrated in the Kalkkop Crater



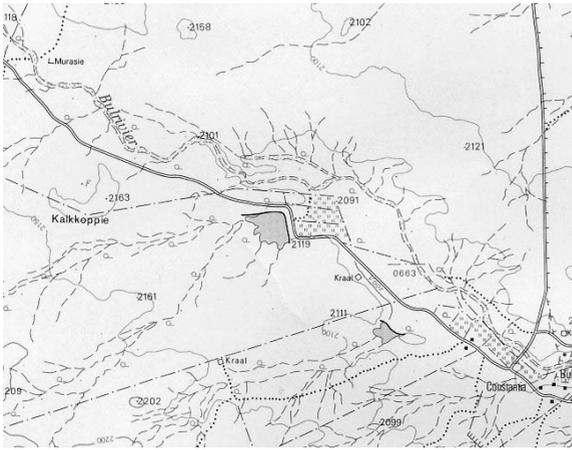
(above) The front cover of the pamphlet written specifically for the Y2KKK dinner (Y2K in the Kalkkop Krater) held inside the Kalkkop crater.



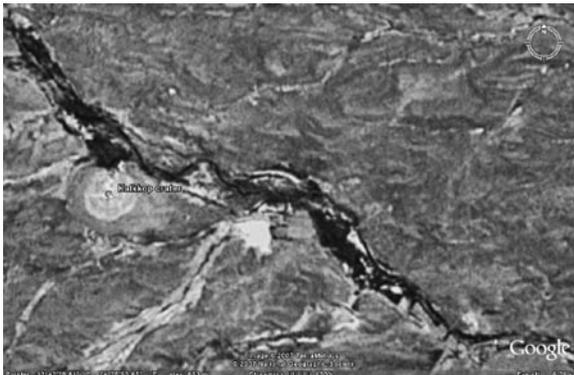
(left) The pamphlet included this diagram, based on research by Dr Jokl le Roux from the former Port Elizabeth Geological Survey showing how the Kalkkop Crater changed over time.

However, I myself had never been to the crater, even though it is not far from where I live. At the end of 2006 our local Union High School astronomy club chose “Impacts – comets, asteroids, meteors and meteorites” as their theme for 2007. A visit to the crater was scheduled for later in the year during our annual “Astronomy Camp”.

January 2007 came. Right on cue, a Great Comet appeared, Comet McNaught, with its magnificent tail. In spite of being far away near the orbit of Mercury, for a while it looked for all the world like something burning up in our atmosphere and about to hit Earth.



A comparison between a 1:50 000 map (above) and a screenshot from Google Earth (below) of roughly the same area. The crater is indicated as “Kalkkoppie” on the map and its white limestone interior shows up clearly on the satellite image.



So by the time we set out for the Kalkkop Crater, we were all fired up about impacts. The 1:50 000 map showed the crater as a little arc-shaped hill called “Kalkkoppie”. Slowly I drove the school bus along the dirt road south of Graaff-Reinet. We had a puncture. I stood and watched while the teenagers displayed their wheel-changing skills. It was getting hot.

At last we arrived at the farm “Constantia”, having previously got permission and directions from the owner, Mr Greeff. He welcomed us and pointed out the small farm road we were to take to the crater. “It is not easy to find,” he warned. The little farm track ran alongside the dry bed of the Bulrivier. Carefully I drove to the place where the crater should be. Up ahead we saw an insignificant hill next to the road. It was



Both these pictures were taken at the centre of the crater. Left is the Union High teenagers who took part in Astronomy Camp 2007. Between their heads the white crater rim is visible in the distance. Below, next to the bus, the flat whitish crater floor can be seen, right out to the rim 300m away. Strictly speaking the actual crater floor is 90m down under the limestone.

sparsely covered in little Karoo bushes, but the ground between them looked white, as opposed to the general earthy colour of the veld all around us. Was this it?

We stopped next to the small white hill. This has to be it, we told ourselves. Up on its rounded top we found thin paper-white slabs of rock lying everywhere. Limestone. We saw that there were other similar low white hills curving away from us more or less in the rough semi-circle the map had shown. But it didn't look like a crater. We could see why no-one at ground level had ever realised what it was.

Down at the borehole in the very middle of the crater we could see its shape better. Standing there on the flat white surface we were just a metre or two lower than we had been on the hilltops. From the borehole we could see that, except for the bit near the river where the crater rim has



eroded away, we were surrounded on all sides by irregular low white ridges, all about 300m away. We were standing at the centre of a 600m-wide white circle.

At the borehole was a cement block in which was hand-printed "1994 380m". (I was puzzled by this, as I had read only of a "1992 drill core".) We unpacked our food and sat there discussing it all. We tried to imagine a meteorite hitting the quiet Karoo veld. We imagined the devastation and how the crater would have looked before it filled with limestone. We spoke

of the mining companies who had drilled there, hoping for gold or uranium, and of the geologists who had drilled to confirm the crater's extraterrestrial origin. And as we ate our picnic lunch we also tried to imagine smartly dressed people eating a three-course candle-lit dinner there. (Apparently the dessert was "Crater Pav-

lova".) When Y2K had successfully been ushered in and the guests had been driven away, the hosts simply abandoned everything there until the next day. The place is so remote that even the drinks could be left in the open quite safely. Thinking of the long slow dirt-road trip back to Graaff-Reinet, we could well believe it. ☆

Kalkkop (S 32° 43', E 24° 26'); identification as an impact crater

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Seventy years ago farmers knew Kalkkop as just a low limestone hill in amongst the sandstones and mudstones of the Karoo. Then in the 1940's aerial photographs revealed that it was a perfectly circular white deposit, 640m in diameter. It was thought that it must be a crater, probably of volcanic origin. In 1947 a mining company drilled a borehole which revealed that the structure contains remarkably pure limestone down to a depth of about 90 metres. Below that lie fragmented rocks of no commercial value (le Roux 2007).

That Kalkkop is an impact crater was not suspected – even many of the craters on the Moon were initially thought to be of igneous origin (Rudaux & Vaucouleurs 1959). Then space exploration changed everything. In 1965 craters were discovered on Mars. In 1969 man landed on the Moon and brought back rocks. Soon

it was realised that the craters there are not formed by volcanism but rather by impacts. Gradually geologists became aware of the ubiquity of impact craters in the Solar System and techniques were developed for the recognition of impact structures on Earth (Hartmann 1977, Reimold et al 1999).

In 1992 a borehole was sunk in the centre of the Kalkkop Crater to a depth of 151.8m. Drilling was suspended for a while and later extended to 380m. (One of the geologists who was there, J.S.V. Reddering, explained that the borehole plaque says "1994" because the drilling took so long. However articles still refer to it as the "1992 drill core" since both these drillings were down the same hole (Reddering 2007)). The drill core revealed that below the limestone lie breccias – rocks made up of angular fragments of pre-existing rocks – showing the

¹ Note that quite a number of Internet articles quote the longitude as 24° 34' instead of 24° 26'.

unique characteristics of impacted rock² (Koeberl et al 1994, Reimold et al 1998).

Samples from the top and bottom of the limestone fill were dated using uranium-thorium series dating. The age of the crater was found to be 250 000 ±50 000 years (Reimold et al 1998). This is similar to the age of the Tswaing Meteorite Crater, the larger and better known crater in Gauteng (Reimold et al 1999).

Analysis of the 1992 drill core included a world first: a technique to confirm its meteoritic impact origin was used for the very first time on the Kalkkop Crater's rocks. Abundances and isotopic ratios of osmium and rhenium were measured, both for the breccias and for

the Karoo sandstones and mudstones (the "target rocks"). The breccias below the limestone showed osmium isotope ratios (187 Os/188 Os) closer to meteoritic compositions than to those typical for continental crust, indicating the presence of about 0.05% of an extraterrestrial component in the breccia. (The meteorite itself would have exploded and vaporised on impact. A small amount of meteoritic vapour would have been incorporated into the fragmented and vaporised target rock, which formed the breccia.) This was the first time that this, now well-established, "osmium isotope systematics" technique had been used to confirm the impact origin of a crater structure anywhere on Earth (Koeberl et al 1994, Koeberl 1997). ☆

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² For those of us who think that "PDF" refers only to a kind of computer file, think again! Meteoritic impact craters, including Kalkkop, contain minerals that are full of PDFs (planar deformation features), microscopic features which form when a mineral is subjected to high-pressure shock waves. PDFs are uniquely associated with impact deformed rocks (Reimold et al 1999).