Exploring the Pingualuit Impact Crater

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Introduction

The Pingualuit Impact Crater, located in northern Quebec at N 61° 16´ W 73° 40´, was the first structure in Canada for which an impact origin was proposed. The structure is classified as a simple crater, 2.8 km in diameter and 400 m deep. It is slightly larger than the smallest crater on the Moon that is observable from our planet (Meen 1951). The inner slope of the 3.4-km-diameter rim averages 30° and the outer slope averages 10°. The rim extends to a diameter of ~4.6 km and continues gradually outward to merge with the surrounding terrain at ~6.6 km. The peak of the rim is ~160 m above the inner lake level and 120 - 150 m above the regional terrain. The lake within the crater, with a depth of over 250 m, is one of the deepest in North America. It is also one of the clearest in the world with a transparency of over 35 m. Dating using the isotope ratio ^{40}Ar-^{39}Ar (Grieve 2006) gives the impact structure an age of 1.4 ± 0.1 Ma.

The Pingualuit Impact Crater was formerly named New Quebec Crater and, previous to that, Chubb Crater.

Field Investigations of the Pingualuit Crater

Pingualuit Impact Crater was first photographed in 1943 by a U.S. Army Air Force aircraft and three years later by the Royal Canadian Air Force (Figure 1). Y.O. Fortier compared the RCAF photograph with a picture of the Barringer Crater in Arizona and proposed a meteoritic origin for the structure. A prospector, Frederick Chubb, knowing that diamonds are sometimes associated with craters in South Africa, proposed that the structure might be a surface expression of a diamond pipe (Marvin, Kring 1992). He approached V. Meen of the Royal Ontario Museum and, together in 1950 and 1951, they made the first expeditions to the crater (Figure 2). Dr. Meen (1950) named the crater after Chubb.

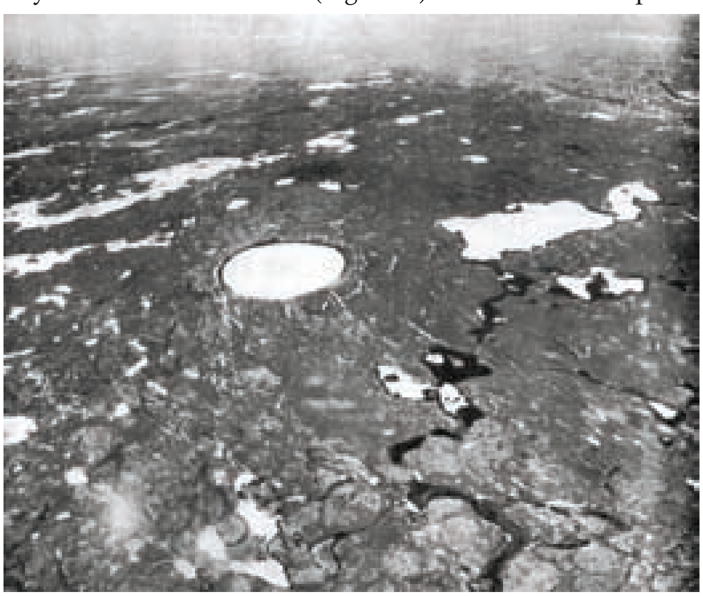

Figure 1 — This aerial photograph from 20,000 feet (6100 m) of the Pingualuit Impact Crater and Lake Laflamme that was taken by the Royal Canadian Air Force in 1946 (Meen 1950). Pingualuit Impact Crater and Lake Laflamme were formerly named Chubb Crater and Museum Lake, respectively.

Meen confirmed that his expeditions did not find any traces of diamonds, volcanic rock, or meteoritic materials at the site of the structure. However, based on his observations, he proposed an explosive event to explain the creation of the structure (Meen 1952). He later stated "We can conclude, therefore, that Chubb Crater is an explosion crater and because of its tremendous size, is due to extra-terrestrial forces. The only such force so far proven to be capable of producing such craters is the impact and explosion of a meteor. No evidence of any sort has been observed that supports a theory of any other origin" (Meen 1957).

Figure 2 — The aerial routes I followed from Ottawa to the crater on both of my expeditions were almost the same as the aerial route of the first expedition by Dr. Meen (1950). Fort Chimo and Wakeham Bay are now called Kuujjuaq and Kangiqsujuaq, respectively.

J.M. Harrison of the Geological Survey of Canada re-examined the crater in 1954. He collected evidence that glaciations had scoured that entire region of the Canadian Shield and deposited erratic boulders on the crater rim and surrounding countryside. Harrison agreed with Meen, stating that "no other process seemed adequate to account for this unique, circular, rimmed bowl in polished granite in a Precambrian shield area with no vestige of recent volcanism" (Harrison 1954).

E.M. Shoemaker explored the area in 1961, and in his view, there remained little doubt of a meteoritic origin. He stated that obtaining critical evidence probably would require drilling through the crater floor (Shoemaker 1962).

The impact origin of the Pingualuit Impact Crater was finally confirmed in 1986 with the discovery of impactite in the vicinity of the structure. J. Boulger found a rounded vesicular pebble 1.75 cm across that was totally unlike any of the country rocks. The sample was sent to the Harvard-Smithsonian Centre for Astrophysics for petrographic examination. A thin section proved to be rich in quartz grains with multiple sets of planar features (Marvin, Kring, and Boulger 1988). Planar deformation features in quartz confirm an impact event (Grieve 2006).

From a Dream to Reality

I first became aware of the Pingualuit Impact Crater in the 1950s while watching Dr. Meen on our old black-and-white television. He was giving an interview describing his expeditions to the crater, and I think that was when the desire to explore that crater for myself first began. It was over 40 years before I could make this dream come true. During those 40 years, I explored many other impact structures in North America from the ground and from the air with my airplane (see `http://ottawa-rasc.ca/wiki/index.php?title=Odale-Articles`).

My first expedition to the Pingualuit Impact Crater was in 2001 with an overflight of the structure. I shared this exploration flight with Terry Peters, a flight instructor and friend. A flight to that remote area of the Quebec Arctic is not a trivial expedition. Our route to the crater approximated the route followed by Meen (Figure 2). The flight from Ottawa to Kuujjuaq (formerly Fort Chimo) was routine, with fuel stops at Chibougamau and Schefferville. The distance to the crater from Kuujjuaq, our only reliable source of fuel in that area, demanded that I make exact calculations of fuel burn, fuel load, and payload to ensure a safe flight between available airports. The weather also has to be factored into the planning to ensure a safe flight. Only by carrying extra fuel on board were we able to spend less than 20 minutes orbiting the Pingualuit Impact Crater and still safely make it to one of the remote airports (Figure 3). At that point, I thought my dreams had come true — as true as practicality demanded, at least.

Eric Kujala, a fellow RASC member, contacted me after he had read the results of my flight to the Pingualuit Impact Crater. That article was also posted on the Ottawa Centre RASC Web site (above). At our first meeting, we agreed to an informal "crater exploration" partnership; our primary desire was to expedite a ground-exploration project to the Pingualuit Crater. We investigated many avenues for access to the crater, even including walking the 90 km from Kangiqsujuaq (formerly Wakeham Bay). In the meantime, we explored many other impact craters on the ground, using Eric's canoe, and from the air, using my airplane.

All our planning efforts changed with the November 2007 opening of the Parc national des Pingualuit, (`http://www.nunavikparks.ca/en/parks/pingualuit/index.htm`). An airstrip was constructed at the crater, which meant that we could make it to the crater by simply chartering an airplane from Kuujjuaq. I could not use my airplane for the final leg of this trip due to the weight and fuel constraints caused by the extra bulk of our camping gear, and because general aviation aircraft are not allowed to land in the park. Finally, in August 2008, we arrived at Pingualuit Crater to spend four days living our dream.

Figure 3 — This was my home for our four-day expedition to the Pingualuit Impact Crater. The rim of the crater is the "small" hill in the far background. You can see the rock field that we had to navigate through to make it to the crater.

An Amateur Investigation of the Pingualuit Impact Crater

Our first day in the crater area was spent setting up our campsite and doing a reconnaissance of the local terrain. It was too late in the day for a productive trip up to the crater. From the campsite (Figure 3), the rim of the crater looked like a small hill in the distance. The temperatures here in August ranged from a pleasant 20 °C during the day to the freezing point at night. The water in my canteen contained ice crystals in the mornings.

Figure 4 — The outer rim of the crater is covered with these granite blocks making it a challenge to climb safely up the 100-m, 10° slope. This rock field surrounded the crater to a distance of over 5 km. Lac Laflamme is in the distance.

Figure 5 — The lake within the crater became visible as we climbed over the flat peak of the rim. The far rim is 3 km in the distance, a challenging hike!

Figure 6 — The 30° inner slope of the rim is an unstable talus slope. I did not attempt to climb down to the water at this point.

Figure 7 — There were numerous gullies that we had to transit during our trip around the crater. The image also gives you a good distance perspective. The people leading the hike are just visible on the rim in the distance.

Figure 8 — Though the depth of the water in this image was over 2 m, the clarity of the water was a sight to behold! At this location, there was a small ledge in the water before the bottom dropped off at the 30° angle of the inner slope. The temperature of the water was just above the freezing level.

Early in the morning of the second day, we proceeded up to the crater rim. The walking was extremely difficult, as the ground in the area is covered with large fragments of rock. The rim rose continuously in the 2.5-km walk from Lac Laflamme (formerly Museum Lake) to the crater. We had to climb over two ridges before reaching the steep slope of the rim itself. The outside rim is composed of a jumbled heap of fragments of granite that cover the surrounding ground for a distance of nearly 5 km (Figure 4).

After a climb of 100 m up a 10° slope, we made it to the top. The rim is so broad that at its peak we could not see the lake inside the crater nor the immediate surrounding terrain (Figure 5). As we walked toward the centre of the crater, we came to a steep 30° descending talus slope. The boulders on the slope were very unstable, making it unsafe for a descent to the lake at that point (Figure 6).

From where we stood, it was over 3-km across to the opposite side of the rim. The rim is highest and widest at its northeast position, giving the crater a lopsided cup shape. It was perfectly silent; we could hear the waves breaking on the inner rim 150 m below us. The distance to the water is very deceptive. It looked so close that it seemed you could easily throw a rock into the lake from where we stood. I tried and didn't even come close to hitting the water!

Our hike around the crater took most of the day and

Figure 9 — This is one of the few *in situ* samples of bedrock that I had found around the crater. This example was completely shattered by the impact over 6 km away. The rim of the crater is the small hill on the horizon.

Figure 10 — This is a 2-m example of the type of impactite that Boulger (1988) had discovered on his expedition in 1986. The 1.4 ±0.1 Ma age of the Pingualuit Impact Crater was determined by ^{40}Ar-^{39}Ar analysis of impactite (Grieve 2006). I placed the caribou antler on the rock for scale.

I have to say it was not one of the easiest hikes that I have experienced. There were frequent and deep gullies along the lip of the rim that we had to transit (Figure 7). Our Inuit guides were extremely helpful in showing us the various unique geological features of the crater, and led us to the only safe descent to the shoreline. The clarity of the lake was amazing to see firsthand (Figure 8). The water temperature was just above freezing. We even found wild blueberries on the inner slope. Being an amateur rock hound, I kept searching, unsuccessfully, for any rock fragments on the crater rim that would have been created by the impact.

I made two trips to the crater during our four-day visit. On the other two days, I explored outside the rim, documenting the effects of the impact on the local geology. The example of shattered bedrock that I found was most compelling. It is difficult to comprehend the magnitude of the impact forces originating more than 6 km distant that caused this rock to shatter so thoroughly (Figure 9). About 5 km east of the crater, I was fortunate to find a large example of impactite (Figure 10). I also experienced a close encounter with a few caribou and found an old Inuit campsite. Unfortunately, I did not find any shatter cones.

Having had Arctic survival training with the military, and now again, experiencing this type of desolate terrain, I stated to our Inuit guides how respectful I am toward their ancestors who could successfully support and feed a family up here. I also have the utmost respect for Dr. Meen's exploration team, who, day after day for a month, climbed to the crater rim from their base camp for their research. The two trips I made to the crater rim totally exhausted me! My exploration of the Pingualuit Impact Crater and local area was very rewarding, an experience I will treasure the rest of my life.

Charles O'Dale is a retired electronic technologist who specialized in semiconductor failure analysis. He has combined his engineering skills with his hobbies of astronomy, geology, and flying to document his explorations of impact structures on this planet. Charles is a member of the Ottawa Centre of the RASC where he served as Chairperson, President, and is currently Ottawa's Past President.

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