THE SUDBURY STRUCTURE

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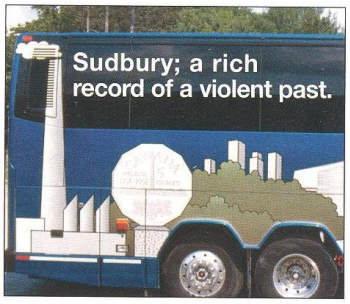
The Sudbury Structure

The Superior Province contains one of the most famous and intriguing features on the surface of planet Earth; the giant **Sudbury Structure** which is some 60 km long, 30 km wide and 10 km deep. It is known worldwide for its rich nickel-copper mines. Much early work on the rich ores, occuring as copper-sulphides, was completed



by the Toronto geologist A. P. Coleman, who also discovered and unraveled the long climate history exposed in the last interglacial sediments of the Don Valley Brickyard at Toronto. He established that the Sudbury structure formed a closed, oval-shaped basin. The increasing use of nickel as an alloy with iron, to produce armour plating for the U.S. Navy after 1890,

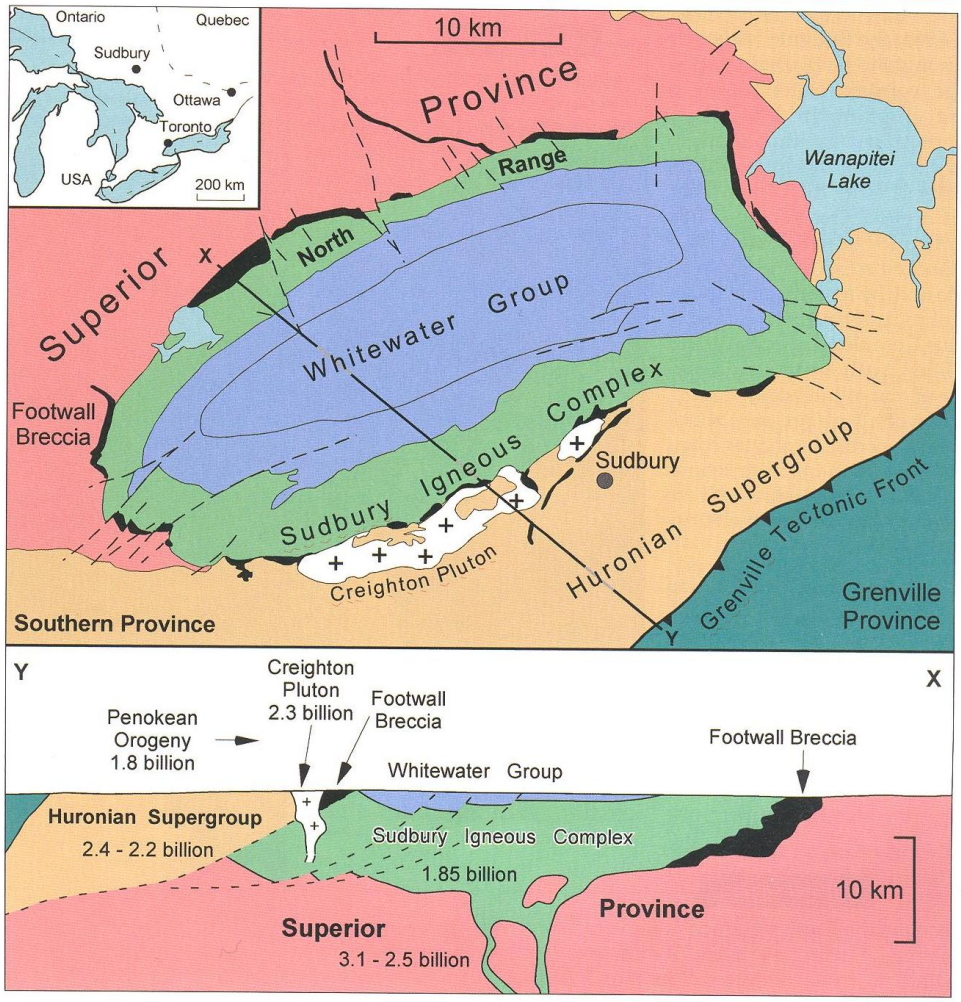


Figure 7-8 In the 1890s, A. P. Coleman described the Sudbury structure as a giant bath tub, inset into the Superior Province. The **Sudbury Igneous Complex** forms the tub and is composed of igneous rocks such as gabbro, norite and granophyre. In turn, it is filled by volcanic and sedimentary rocks of the **Whitewater Group**. The tub is lined by intensely broken rock called breccia forming the **Footwall Breccia** and **Sudbury Breccia**.

promoted commercial interest in the Sudbury ores, and Coleman's maps and reports were later described as "truly remarkable documents for the wealth of information they contain". The modern nickel industry in Canada is indebted to Coleman. The Sudbury basin produces about 15% of the world's current nickel supply and some 9 million tonnes of nickel have been produced over the past 100 years.

Figure 7-9 Nickel-copper ore from Sudbury is composed of **stringers** of minerals such as yellow chalcopyrite (copper sulphide), pentlandite (nickel-iron sulphide) and nickeliferous pyrrhotite (iron sulphide). These crystallized during the cooling of a sulphur-rich magma triggered by meteorite impact. Larger darker-coloured fragments are various "country rocks" that underlie the structure and which were mixed with the impact melt.

A shocking revelation

Until 1964, the Sudbury structure was thought to have originated as a large volcanic crater during a violent eruption. In 1964, R. S. Dietz proposed an impact origin by an enormous meteorite with a diameter of more than 4 km. This, it was argued, created the crater, accounted for the thick brecciated and shocked rocks of the Footwall Breccia and, by melting great quantities of rock, formed the Sudbury Igneous Complex. Later, the crater was filled with water and sediments of the Whitewater Group. Evidence of a high pressure shock wave is supported by shatter cones which mimic man-made structures produced by rock blasting and are associated with known meteorite impact craters.

While the origin of the structure and its associated ores is still debated, geologists speak of a catastrophic "Sudbury Event" some 1.8 billion years ago. It is likely that the Sudbury Structure was originally circular and was squeezed to form an oval shape during the subsequent Penokean Orogeny. During this orogeny, the Huronian Supergroup

Did you *know* ...

Until the late nineteenth century, nickel was regarded as a nuisance in the smelting of copper ores. It derives its name from the German word **"Kupfernickel"** meaning "Old Nick's Copper", a reference to the Devil. The rich copper-nickel ores at Sudbury were discovered in 1883 when the Canadian Pacific Railway was being constructed through the area. In 1891, the Orford Copper Company developed a means of recovering nickel from the copper ores and, in 1902, the International Nickel Company (Inco) was formed.

Figure 7-10 Shatter cones. Photo courtesy Ontario Geological Survey

Did you *know* ...

Because the Earth's surface is geologically active, many impact craters have been eroded and lost. As a result, direct evidence of meteorite impacts during the earliest history of the Earth is missing; to date no Archean craters older than 2.5 billion years have been discovered. In contrast, the Moon's surface retains a record of more than 200 impact craters greater than 1,000 km wide. These formed between 4.6 and 3.8 billion years ago and provide a clue as to the number of impacts on the early Earth. Geologists speculate that earliest oceans on planet Earth were repeatedly vaporized by colossal impacts (to re-form by condensation from the atmosphere) making life impossible until after 3.8 billion years ago when the intense bombardment ceased.

was thrust against the Sudbury Structure. We shall explore this orogeny in the next chapter as it gave rise to a new and enlarged North American continent called **Nena**.

A crushing experience

Good evidence of a huge impact at Sudbury is provided by breccia-like rocks called **pseudotachylytes** and **suevites**. The former occur as steeply-dipping dike-like bodies up to 1 km wide, marking the site of faults made by the impact; existing rocks were crushed and partially melted by intense friction during faulting (e.g., Sudbury Breccia and Footwall Breccia). **Suevites** are composed of impact debris thrown into the atmosphere and which fell back into the crater forming an extensive blanket-like body such as the Onaping Formation whose volume has been estimated at 1,250 km^3. Intense pressures created by a giant meteorite impact are also recorded by "shocked" quartz crystals in the rocks that surround the Sudbury structure.

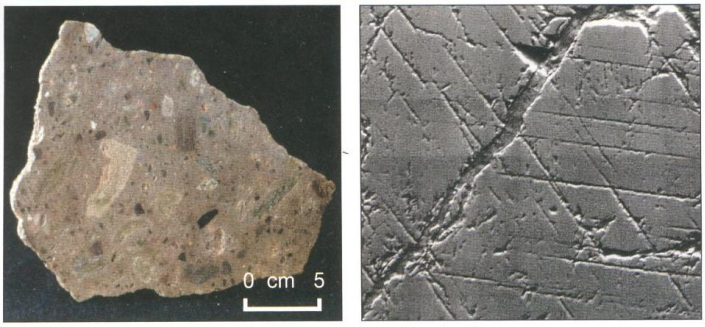


Figure 7-11 **(A)** Pseudotachylyte. **(B)** Shocked quartz crystal with veins of pseudotachylite and criss-crossing fractures. Width of veins is 3mm. Courtesy Arthur Mory.

Figure 7-12 This is a fragment of an iron meteorite that fell over the Sikhote Alin Mountains of eastern Siberia on February 12, 1947. It shows a beautiful glossy fusion crust with many small pits (called **regmaglypts**) resembling thumb prints. These form by partial melting of the outer surface of the meteorite. When cut and polished it shows the characteristic Widmanstatten crystallisation pattern.