Coarse sperrylite crystals

from Sudbury, Ontario

"Rock of the Month # 81, posted for March 2008" ---

Sperrylite (platinum diarsenide, $PtAs_2$), occurs here in mm-scale grey-white crystals with bright metallic lustre, dispersed along a quartz veinlet cutting an igneous host rock. The sample is from the Vermilion mine, the type locality of sperrylite. It is located in Denison township, in the Whitefish area, some 35 km west of the city of Sudbury. This ore sample, although a modest mineral specimen, is a particularly platinum-rich product of the Sudbury igneous complex, a remarkable suite of rocks generally ascribed to a major impact event age dated at 1850 Ma. Sudbury is considered the second-largest impact structure known, after the Vredefort structure of South Africa. The SIC supports the foremost Ni-Cu-PGE mining camp in the Americas. This is a PGE-rich sample, with at least 24 small crystals of shiny, silvery sperrylite in a quartz-sulphide veinlet which forms one side of this 9x4.5x3-cm piece. The bulk of the sample is the fine-grained, dark grey wallrock of the vein, apparently a massive diorite, carrying disseminated tarnished chalcopyrite plus bright green chlorite. The photograph displays the plane of the vein, filled largely with grey quartz. The host rock is best seen at the left end. Sperrylite crystals form silvery highlights towards both left and right-hand ends of the trace of the vein. Sample 1184, acquired from Lismark (Barrie, ON) circa 1989.

Sperrylite, first described in 1889, is one of the best-known platinum-group minerals (PGM*). It is distributed worldwide, in primary (bedrock), alluvial and glacial (overburden) media, and is known from most major PGE-bearing mining camps and many lesser PGE deposits, including the Bushveld and Witwatersrand in South Africa;

the Great Dyke of Zimbabwe; Noril'sk-Talnakh in Siberia; the Stillwater complex in Montana, USA; the Sudbury nickel camp in Ontario, Canada; the Jinchuan intrusion in China; and the Panton sill and Kambalda nickel camp, both in Western Australia. Sperrylite is also reported from numerous localities across Canada, Greenland, Spain. Finland, Russia, India, Brazil and other countries. It occurs in the Mesoproterozoic mafic-ultramafic rocks of the **Midcontinent Rift** of North America, age dated at circa 1100 Ma, at localities along and near the northern shores of Lake Superior within the Duluth complex (Minnesota, USA), the Seagull complex and the Coldwell complex (these last both in Ontario, Canada). It is also reported as micron-scale grains in the rare Rumuruti-type carbonaceous chondrite **meteorites**. It is often the most abundant platinum mineral species in a deposit, bearing in mind that platinum tends to form far fewer discrete mineral species than palladium, in the same way that the mineralogy of gold is much less diverse than that of silver. 51% of 280 MINLIB records mentioning sperrylite, 1889-2008, were published between 1991 and 2008, a testament to the sustained academic interest in PGE-rich deposits in the past two decades. The following discussion merely scratches the surface of all this research.

Sperrylite *vignettes*: Cabri (2002) provides a detailed, up-to-date review of PGM species. Sperrylite is commonly one of the most abundant PGM, given adequate arsenic in the melt, and it is important to account for any coarse material when preparing geochemical reference materials, such as the now-depleted **Merensky Reef** standard SARM 7 (Anon, 1975). The key Reef PGM include ferroplatinum, cooperite, sperrylite, braggite and moncheite. Sperrylite may comprise over 50% of the PGM population (Brynard *et al.*, 1976). Sperrylite is often associated with chalcopyrite in sulphide ores (e.g., Hudson, 1986), and sometimes with magnetite (e.g., Cabri *et al.*, 1991). Sperrylite may also be hosted in silicates such as plagioclase, amphibole and chlorite (e.g., Cornelius and Stumpfl, 1989).

The **Rottenstone** deposit in Saskatchewan, intermittently mined from 1965-68, displayed briefly the highest PGE mine grade of primary magmatic sulphide mined in Canada (Hulbert and Paktunc, 1989). It provides a good example of rich ore with complex metallurgical characteristics. The three principal PGM, in decreasing order of abundance, were sperrylite, kotulskite and michenerite. Analyses of mineral grains by proton microprobe (proton-induced x-ray emission, PIXE) revealed that some fellow metals were also enriched in more-common minerals in solid solution, e.g., pentlandite can carry up to 17 ppm Pd, 20 ppm Ag and 139 ppm Se, while chalcopyrite carried up to 83 ppm Ag and 151 ppm Se. Besides common base-metal sulphides, metals of interest occurred as Bi and Ag tellurides and electrum (Au-Ag alloy).

Sperrylite commonly occurs quite late in the ore-mineral paragenesis. Johan *et al.* (1991) describe grains from Australian, Alaskan-style ultramafic complexes in which later PGM such as geversite and sperrylite result from reaction of early PGM with a fluid phase, replacing cooperite. Small Pan-African intrusions (age dated at 790 Ma) in Madagascar were probably emplaced on deep-seated strike-slip faults active under amphibolite to granulite facies regional metamorphism, forming funnel-shaped magma chambers and feeder dykes. PGE, base metals and arsenic may be related to magmatic fluid which

separated early when orthopyroxene appeared at the liquidus: interaction of these fluids with older ultramafic rocks formed PGE mineralization, including sperrylite (Ohnenstetter *et al.*, 1991).

The **Great Dyke of Zimbabwe** offers some interesting examples of the complexities of PGM distribution in a magma chamber, with different species predominant in specific environments. Thus, at the Hartley platinum mine, most Pd and Rh are hosted in pentlandite, but Pt occurs mostly in discrete PGM species. In the lower, PGE-rich subzone of the MSZ (main sulphide zone), sperrylite occurs throughout, while cooperite and braggite are mostly confined to the basal part, and Pt-Pd-Bi tellurides occur largely toward the top (Oberthur *et al.*, 2003a). Erosion of the host rocks and the onset of weathering can redistribute the metals. Pd is more mobile in the supergene setting, and is lost relative to Pt. Sperrylite and cooperite/braggite are stable in the oxidized zone, whereas Pt- Pd- Bi tellurides disintegrate and ill-defined PGE oxides / hydroxides result (Oberthur *et al.*, 2003b).

Sperrylite in Sudbury: The **Sudbury** mining camp is a large, complex and unique cluster of PGM localities. The principal PGM are michenerite, sperrylite and moncheite (Cabri, 1981; Dressler *et al.*, 1991). In an analysis of concentrate from the Clarabelle primary mill, Copper Cliff, some 83% of assayed Pt occurred in sperrylite (Cabri and Laflamme, 1984). The metallurgical mass balance accounted for more of the Pt (91%) than any of the other PGE, which are variously present in solid solution and as small grains of other PGM species. Michener (1940) undertook an early study of PGM at Sudbury, with emphasis on the Frood and Creighton mines. At Frood, arsenides are most abundant along the contacts of the orebodies, as a thin selvage between the sulphide ore and the hangingwall rocks, and as veins and stringers within the altered host rock. Quartz, carbonate, hastingsitic amphibole and biotite are usually present. Michener found sperrylite in Sudbury ores as crystals 0.005 to 5 mm in size. It was found especially in Frood ores embedded in chalcopyrite streaks, in the Ni arsenide zone at contacts, and in massive sulphides from the lower levels of Frood. The phase PdBiTe, found at from Frood was named for the author, **michenerite**, in 1958.

Cabri *et al.* (1988) reviewed the recovery of PGE from Ni-Cu-PGE ores. At Inco's mines in **Sudbury**, the sulphides are mostly chalcopyrite and pentlandite, plus magnetic monoclinic pyrrhotite and nonmagnetic hexagonal pyrrhotite. Flotation separates these major phases, but a significant amount of PGM grains are lost to the tailings. Almost all Cu and 85% of the Ni are available for recovery by flotation at a coarse grind of 50-60% to -74 microns (200 mesh). The balance of the Ni is associated with fine-grained pyrrhotite, and a fine regrinding frees up more of the Ni. The Pt:Pd:Rh ratio at Inco was about 0.47:0.49:0.04. Sperrylite and michenerite are the main PGM, and the bulk Cu+Ni concentrate assays 1.4 ppm combined PGE plus Au. In comparison, on the **Merensky Reef**, bulk sulphide flotation with a coarse grind of 40-50% -74 microns (200 mesh) is adequate, and the reported mill grade is 7.4 ppm combined PGE+Au, with Pt:Pd:Rh ratios of 0.68:0.29:0.03. 82-85% of PGE+Au are recovered in a flotation concentrate assaying 66 ppm (PGE+Au), and about 15% of the PGE are lost in the flotation tails. Overall PGE recovery in Canadian Ni+Cu smelters is said to exceed 95%.

Sperrylite specimens: The Vermilion mine has provided the bulk of Canadian specimens. Most very-large (>5 mm) sperrylite specimens have been recovered from the Bushveld and especially from Noril'sk-Talnakh. Sperrylite was first described in detail from the Vermilion mine, the type locality, which was first reported as a gold discovery in October 1887 (Wells, 1889; Penfield, 1889; Gait, 1982). The material was provided by Francis L. Sperry, chemist at the Canadian Copper Company.

Russian specimens figured and described in print are mostly from the **Oktyabr'sky mine, Noril'sk**: see Barlow *et al.* (1996, p.209); Wilson *et al.* (2000, p.32); Larson (2002); Moore (2002); and Trinchillo (2008, p.11). The samples from the Noril'sk-Talnakh orefield will eventually become harder to obtain, as the principal host deposit of the crystal specimens is largely worked out (Moore, 1996, p.221). This said, a superb example with a complex 1.5-cm crystal, "probably the world's finest specimen of the species", was featured on the cover of the March 1998 edition of Mineralogical Record. Lastly, a truly remarkable 3.8-cm sperrylite cluster in chalcopyrite from Oktyabr'sky mine, Talnakh, Noril'sk, Siberia from the Herb Obodda collection is one of the finest ever (White, 2008, p.327). The Noril'sk camp is the world's pre-eminent Pd producer and (McGlasson and Moore, 2001) some 90-95% of the Pt there is found in sperrylite. Euhedral sperrylites of micromount size, up to 0.5 mm or more, may also be preserved in surficial media, such as placer deposits in northern Finland (Koivisto *et al.*, 1980).

* **A Word on Terminology**: Students of the platinum family of precious metals should usefully distinguish the individual metals, the platinum group elements (**PGE**) from their most concentrated host minerals (**PGM**). Note however that investors, financiers, miners and trade writers in general tend to neglect this geochemically and metallurgically important distinction, and refer to the metals as **PGM**, platinum group metals.

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Graham Wilson, posted 04 July 2008, extended 04 August 2008, expanded 12 September 2008.

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See sperrylite in polished specimen of PGE-rich sulphide concentrate, from **Noril'sk**.

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