GS-12 PLATINUM GROUP ELEMENT INVESTIGATIONS IN THE FLIN FLON GREENSTONE BELT: PETROGRAPHY AND MINERALOGY OF THE MCBRATNEY LAKE PGE-AU OCCURRENCE (NTS 63K13), MANITOBA

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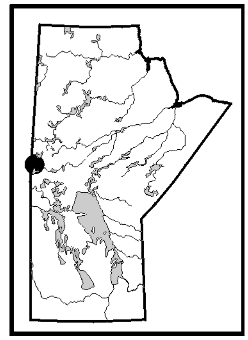

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SUMMARY

The McBratney Lake PGE-Au occurrence is an example of hydrothermal PGE-Au mineralization, which is hosted by the mafic volcanic rocks of the Bear Lake basaltic andesite unit in the Flin Flon greenstone belt. This occurrence is characterized by extensive carbonate-chlorite-sulphide alteration and contains various platinum group minerals (PGM). They are, in order of abundance, borovskite (Pd_3SbTe_4), two unknown Pd telluride-antimonide minerals, sudburyite (PdSb), sperrylite ($PtAs_2$), temagamite (Pd_3HgTe_3) and merenskyite ($PdTe_2$). They commonly occur as inclusions in chalcopyrite, pyrite and carbonate, and are replaced by cobaltite-gersdorffite. Electrum (Au-Ag alloy) is also associated with the PGM and occurs included in chalcopyrite.

INTRODUCTION

The McBratney Lake PGE-Au occurrence, hosted by the mafic rocks of the Bear Lake Block in the Flin Flon greenstone belt, is located approximately 7 km east of the town of Flin Flon (Fig. GS-12-1a). This occurrence has been referred to as a ‘contact-type’ PGE occurrence, based mainly on field observations (Theyer, 2001); however, little is known about the alteration, precious metal mineralogy and paragenetic sequence of this occurrence. The purpose of this report is to summarize the findings of a preliminary investigation of the McBratney Lake PGE-Au occurrence, focusing on the petrography and mineralogy of the mineralized zones. The samples studied here were collected in the summer of 2001 in the stripped high-grade PGE-Au zone (up to 31 g/t Pd and 9 g/t Pt; Fort Knox Gold Resources Inc., press release, Aug. 13, 2001) of the McBratney Lake property (Fig. GS-12-1b).

GEOLOGY

Bear Lake Block

The McBratney Lake PGE-Au occurrence is hosted in the Bear Lake basaltic andesite, close to a gabbroic intrusive body (Theyer, 2001) that is interpreted to be related to the Wonderland gabbro, which is part of the Bear Lake Block (Bailes and Syme, 1989). This tectonic block is part of the 1.8 to 1.9 Ga Flin Flon greenstone belt (Syme et al., 1987; Gordon et al., 1989), which is composed of the following eleven units (from bottom to top; Bailes and Syme, 1989): Bear Lake basaltic andesite (3300 m thick), heterolithic breccia (150 m), Solodiuk Lake rhyolite (250 m), White Lake dacitic tuff (300 m), Little Spruce Lake andesitic lapilli tuff (350 m), mudstone and massive sulphide mineralization (25 m), Two Portage Lake ferrobasalt and rhyolite crystal tuff (200 m), Vick Lake andesitic tuff (900 m), dacite tuff (100 m) and intermediate tuff and breccia (30 m). These units form an east-facing homoclinal structure and are bounded to the west by the Inlet Arm Fault and to the east by the Northeast Arm Fault. In addition to the PGE-Au occurrences, the Bear Lake Block hosts two Cu-Zn massive sulphide deposits (Cuprus and White Lake mines) and a Au-rich Zn massive sulphide deposit (Westfield deposit).

Bear Lake basaltic andesite and Wonderland Lake gabbro

The Bear Lake basaltic andesite comprises aphyric to pyroxene- and plagioclase-phyric lava flows, breccias with pillow fragments, abundant synvolcanic dikes and sills, and very minor interflow tuff (Bailes and Syme,1989). In the summer of 2002, a geological survey was conducted in the vicinity of the McBratney Lake occurrence and drill cores that intercepted the mineralized zones were described in detail and sampled. Access to the core was provided by Hudson Bay–Anglo American and Fort Knox Gold Resources Inc. The following five distinct zones were documented in the Bear Lake basaltic andesite: 1) pillow basalt, with intense epidote alteration; 2) amygdaloidal basalt with epidote alteration; 3) breccia, composed mainly of pillow fragments; 4) medium-grained, mafic volcaniclastic rocks with fragments of plagioclase crystals in a Mg-chlorite matrix; and 5) fine-grained mafic volcaniclastic rocks with fragments

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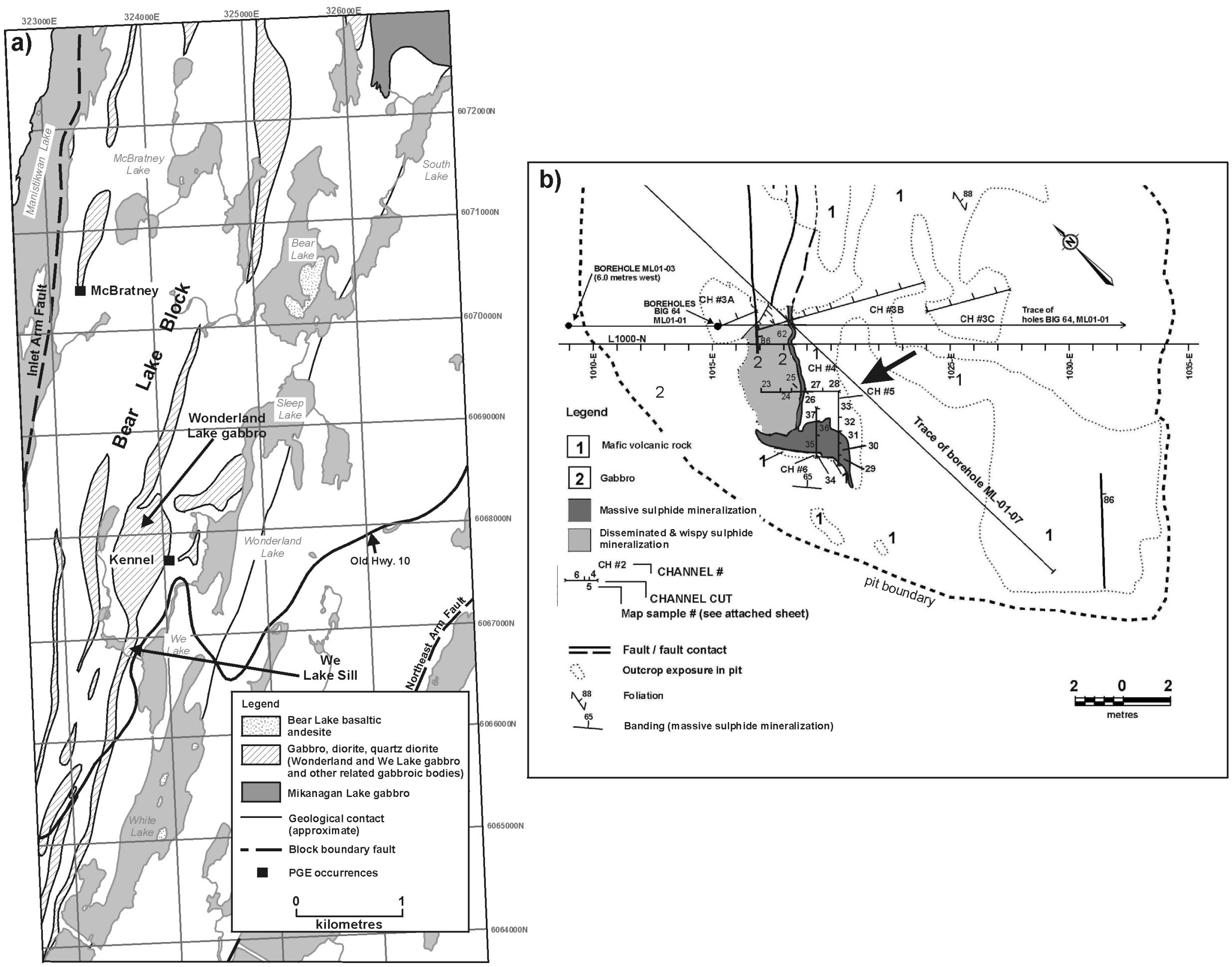

Figure GS-12-1: a) Simplified geological map of the west part of the Bear Lake Block, showing the location of the McBratney Lake PGE-Au occurrence (modified after Bailes and Syme, 1989; Theyer, 2001). b) Simplified geological map of the south part of the McBratney pit, showing locations of the studied samples (modified after Theyer, 2001).

of plagioclase crystals in a Fe-chlorite matrix. These rocks are deformed and, in the vicinity of the mineralization, intensively foliated and locally brecciated. Their contacts with gabbroic dikes and sills are tectonic, characterized by shear faults (Fig. GS-12-2a) with local intense veining. These gabbroic intrusions are tentatively correlated with the Wonderland Lake gabbro unit, which was described by Bailes and Syme (1989) as containing mainly gabbroic rocks in the western half of the intrusion and more evolved quartz diorite in the eastern part. They are also described by Theyer and Heine (GS-X31, this volume). In the field and in drill cores, various generations of the mafic dikes and sills are cut by irregular masses of leucocratic gabbro-diorite (Fig. GS-12-2b). Textures and structures observed in the field suggest that magma mixing was an important process during the formation of these gabbroic rocks. Near the Kennel occurrence (Fig. GS-12-1a), the gabbroic rocks contain fragmented layers of massive magnetite (Fig. GS-12-2c).

PETROGRAPHY AND MINERALOGY

Seven samples from channels #4 and #5 of the McBratney pit were selected for detailed petrographic and mineralogical investigations (*see* Fig. GS-12-1b for locations). The mineralized samples, which are hosted by the Bear Lake basaltic andesite, are layered and/or brecciated and cut by veinlets. They are composed mainly of sulphide minerals, cobaltite-gersdorffite, chlorite, carbonate, biotite and minor muscovite, plagioclase, magnetite, coloradoite, electrum and PGM. Plagioclase occurs as phenocrysts that are partially altered to chlorite or carbonate. Chlorite and carbonate commonly fill irregular veinlets or patches, and locally occupy corroded zones in plagioclase and sulphide minerals, or pseudomorphously replace a mafic phase. Some of the veinlets comprise alternating layers of chlorite and carbonate, indicating various episodes of open-space filling. Biotite laths are either associated with carbonate or included in sulphide minerals. Partially corroded magnetite euhedra occur within chalcopyrite and locally contain inclusions of PGM.

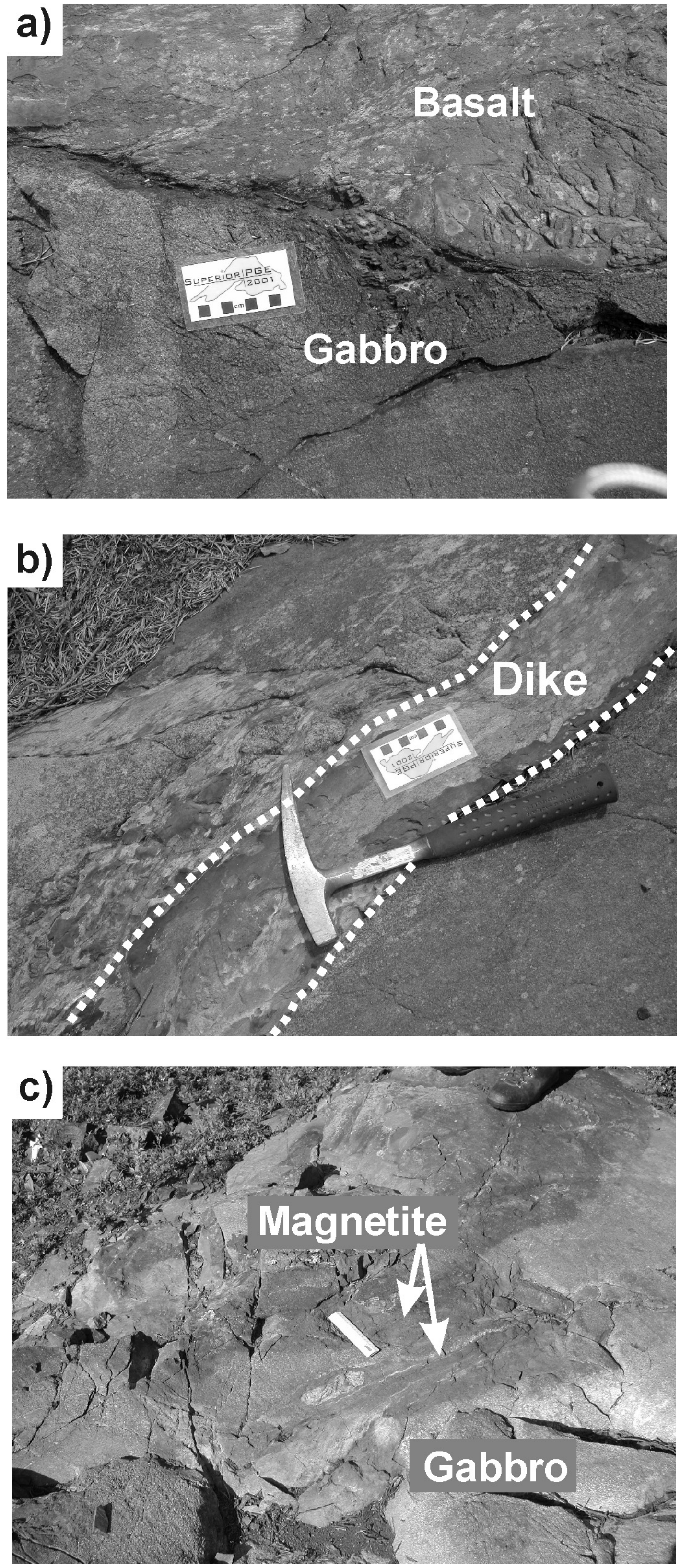

Figure GS-12-2: a) Contact between mafic dike of the Wonderland Lake gabbro and pillow basalt from the Bear Lake basaltic andesite. b) Fine-grained diabase dike cutting the main gabbroic unit of the Wonderland Lake gabbro. c) Magnetite layers in the Wonderland Lake gabbro.

The sulphide minerals are pentlandite, Ni-bearing pyrrhotite, pyrite, bravoite, marcasite, chalcopyrite, millerite, sphalerite and galena. Pentlandite is almost completed altered, forming boxworks. Pyrrhotite forms irregular masses and is commonly altered and replaced by pyrite and millerite. Pyrite occurs in fractured aggregates of cubic euhedra and is locally intergrown with bravoite and replaced by marcasite and cobaltite-gersdorffite. Chalcopyrite forms irregular patches and commonly fills embayments in the margins and fractures of pyrite and pyrrhotite. Sphalerite is very rare and occurs included in chalcopyrite, where it is spatially associated with electrum. Galena forms irregular grains and is commonly found in carbonate veinlets. Cobaltite-gersdorffite commonly replaces the Ni-, Fe- and Cu-bearing sulphide minerals, electrum and PGM. Coloradoite (HgTe) is rare and forms composite grains with other PGM. Electrum (20–30 wt% Ag) euhedra are included in chalcopyrite, where they are locally associated with sphalerite. Corroded electrum grains are commonly surrounded by cobaltite-gersdorffite.

The most common PGM are (Fig. GS-12-3) borovskite (Pd_3SbTe_4), sudburyite (PdSb) and two unknown minerals, whose optical properties and compositions differ from the Pd minerals reported in Cabri (2002). Sperrylite ($PtAs_2$), temagamite (Pd_3HgTe_3) and merenskyite ($PdTe_2$) are rare. Borovskite occurs as euhedral grains (up to 0.2 mm in diameter), commonly included in chalcopyrite and pyrite, and locally as composite grains with merenskyite, sperrylite and temagamite. Sudburyite (up to 0.2 mm) occurs as euhedral grains included in chalcopyrite or carbonate, or as corroded grains mantled by cobaltite-gersdorffite. Sperrylite (up to 30 µm) forms composite grains with borovskite and the unknown PGM. Merenskyite (up to 50 µm) is rare and occurs as composite grains with borovskite and temagamite, as free grains in corroded zones between chalcopyrite and cobaltite-gersdorffite, or included in magnetite. Temagamite (up to 50 µm) was found in composite grains with borovskite-merenskyite, or with one of the unknown PdSbTe phases. The mode of occurrence of the various PGM is shown in Figure GS-12-3, and their compositions are reported in Table GS-12-1.

DISCUSSION AND CONCLUSIONS

The petrographic and mineralogical data suggest that the McBratney Lake mineralization is hydrothermal and the major ore minerals are found in carbonate-chlorite veins or replacement zones in the Bear Lake basaltic andesite. Palladium forms mainly telluride-antimonide minerals; however, Pt forms arsenide minerals and Hg is commonly associated with the former. Most of the PGM and electrum precipitated contemporaneously with pyrite and/or chalcopyrite, which replace and fill veins in the mafic volcanic rocks. Sulphide minerals, PGM and electrum were later replaced by cobaltite-gersdorffite, which is one of the latest phases to precipitate. Curiously, Au is alloyed with Ag and its PGE content is lower than the microprobe detection limit. In other Pd-rich hydrothermal occurrences, Au commonly forms alloys with Pd (Olivo and Gauthier, 1994; Olivo et al., 1995; Olivo and Gammons, 1996; Olivo et al., 2001 and references therein).

Other aspects related to the geology and genesis of this hydrothermal PGE-Au occurrence are being investigated by Natalie Bursztyn and Gema Olivo, and include petrographic, mineralogical, geochemical and isotopic characterization of the host unit, the PGE-bearing sulphide lenses/veins and the barren ones, as well as a study of the hydrothermal fluids associated with this mineralization.

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REFERENCES

Bailes, A.H. and Syme, E.C. 1989: Geology of Flin Flon–White Lake area; Manitoba Energy and Mines, Geological Services, Geological Report GR87-1, 313 p. and 2 maps.

Cabri, L. J. 2002: The platinum group minerals; *in* The Geology, Geochemistry, Mineralogy and Mineral Beneficiation of Platinum group Elements; L. Cabri (ed.), Canadian Institute of Mining, Metallurgy and Petroleum, Special Volume 54, p. 483–506.

Gordon, T.M., Hunt, P.A., Bailes, A. and Syme, E.C. 1989: U-Pb zircon ages from the Flin Flon and Kisseynew belts, Manitoba: chronology of crust formation at an Early Proterozoic accretionary margin; *in* The Early Proterozoic Trans-Hudson Orogen: Lithotectonic Correlations and Evolution, J.F. Lewry and M.R. Stauffer (ed.), Geological Association of Canada, Special Paper 37, p. 177–200.

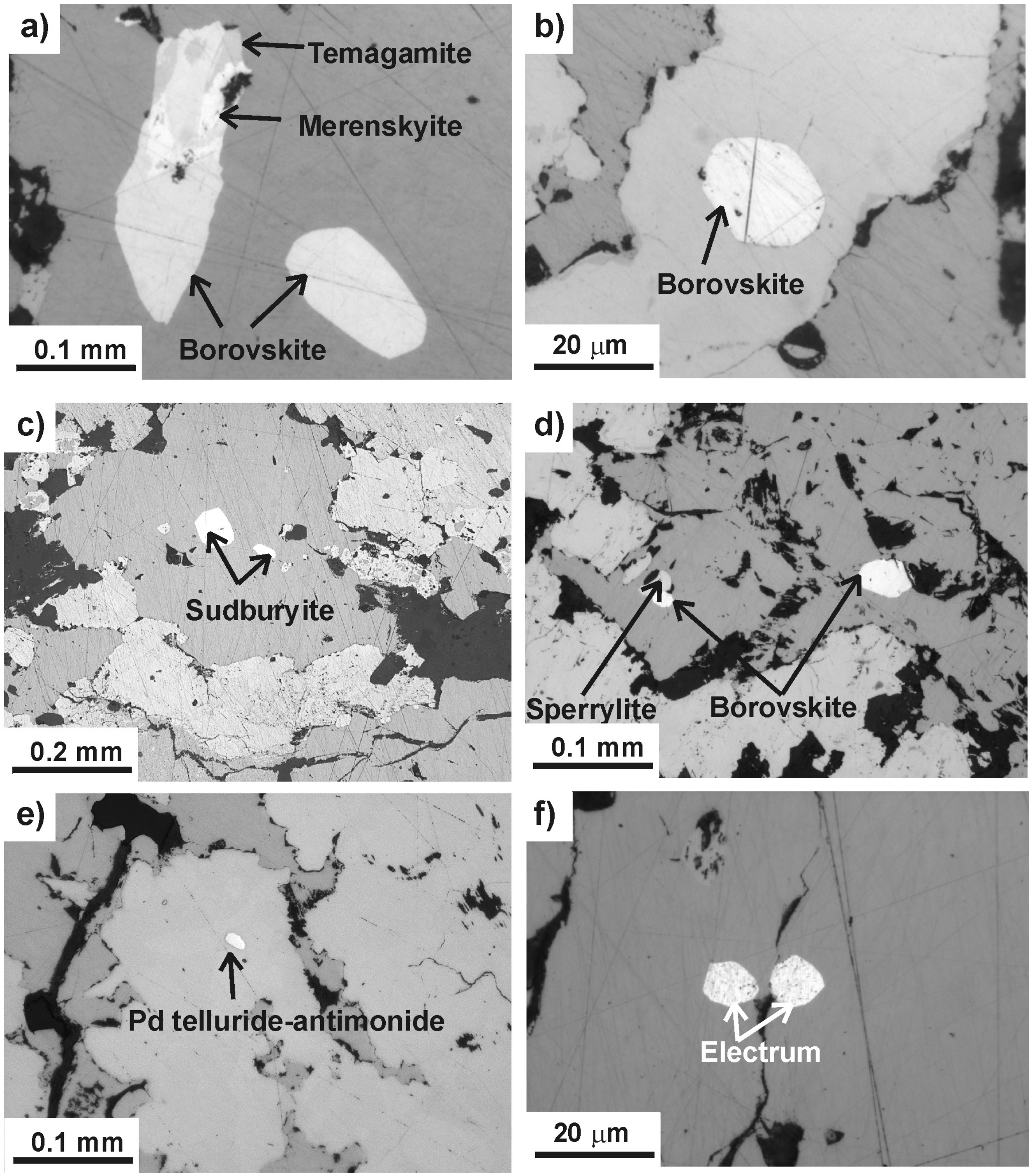

Figure GS-12-3: Platinum group minerals from the McBratney Lake PGE-Au occurrence: a) borovskite-temagamite-merenskyite composite grain (large grain) and borovskite euhedrum included in chalcopyrite; b) borovskite euhedrum included in pyrite; c) sudburyite euhedra included in chalcopyrite; d) borovskite-sperrylite composite grain included in chalcopyrite; e) unknown Pd telluride-antimonide mineral included in pyrite; and f) two electrum grains included in chalcopyrite.

Table GS-12-1: Composition of the platinum group minerals from the McBratney Lake PGE-Au occurrence.

Element	Borovskite (n=27)	Sudburyite (n=10)	Merenskyite (n=2)	Temagamite (n=3)	Sperrylite (n=8)	Unknown-1 (n=23)	Unknown-2 (n=11)
Pd	27.9–31.6	41.6–46.1	27.0–29.4	33.1–35.7	0.0–0.2	41.8–45.6	31.1-33.4
As	n.d.	n.d.	n.d	n.d	43.6–44.6	n.d.	0.2-0.3
Hg	n.d.	0.4–3.9	n.d	20.3–21.9	n.d.	0.6–1.7	n.d
Sb	13.5–14.2	44.3–52.4	0.8–4.6	n.d	n.d.	39.4–42.4	20.9-21.6
Pt	n.d.	n.d.	n.d.	n.d	54.3–55.6	0.0–0.1	n.d
Te	51.2-52.6	0.4–7.8	63.8–64.9	34.7–40.7	n.d.	10.1–15.2	42.5-43.7
Cu	n.d.	n.d.	n.d	n.d	0.0–0.1	n.d.	n.d
Ag	n.d.	n.d.	n.d	n.d	0.2–0.4	0.0–0.1	n.d
Ni	1.1–3.2	0.0–0.7	0.0–0.1	0.3–1.5	0.0–0.7	0.0–0.6	1.7-1.9
Bi	1.2–1.7	0.1-0.3	0.5–0.8	0.0–0.1	0.0–0.1	0.2–0.6	0.2-0.5
Co	0.0–0.5	n.d.	0.0–0.2	n.d.	n.d.	n.d.	n.d
Fe	0.1–1.7	0.1–1.2	0.4–1.9	0.6–0.8	0.5–1.7	0.0–1.2	0.1-1.3
Total	99.1–101.4	98.5–100.0	95.7–98.8	98.4–100.6	99.4–101.5	98.9–100.8	99.9-101.0

n.d., not detected

Olivo, G.R. and Gauthier, M. 1994: Palladian gold from the Cauê iron mine, Itabira District, Minas Gerais, Brazil; Mineralogical Magazine, v. 58, p. 579–587.

Olivo, G.R. and Gammons, C.H. 1996: Thermodynamic and textural evidence for at least two stages of Au-Pd mineralization at the Cauê iron mine, Itabira District, Brazil; Canadian Mineralogist, v. 34, p. 547–557.

Olivo, G.R., Gauthier, M., Bardoux, M., Leao de Sa, E., Fonseca, J.T.F. and Santana, F.C. 1995: Palladium-bearing gold deposits hosted by Proterozoic Lake Superior–type iron-formation at the Cauê iron mine, Itabira District, Southern Sao Francisco Craton, Brazil: geologic and structural controls; Economic Geology, v. 90, p. 118–134.

Olivo, G.R., Gauthier, M., Williams-Jones, A.E. and Levesque, M. 2001: The Au-Pd mineralization at the Conceição iron mine, Itabira District, Southern São Francisco Craton, Brazil: an example of a “jacutinga-type” deposit; Economic Geology, v. 96, p. 61–74.

Syme, E.C., Bailes, A.H., Gordon, T.M. and Hunt, P.A. 1987: U-Pb zircon geochronology in the Flin Flon: age of the Amisk volcanism; *in* Report of Field Activities 1987, Manitoba Energy and Mines, Minerals Division, p. 105–107.

Theyer, P. 2001: Platinum group element investigations in the Flin Flon greenstone belt: McBratney Lake occurrence and Josland Lake intrusion (parts of NTS 63K/9, /13); *in* Report of Activities 2001, Manitoba Industry, Trade and Mines, Manitoba Geological Survey, p. 33–39.