

Chapter 10

International tantalum resources — exploration and mining

This chapter examines the tantalum resources outside of Australia, not just in terms of resource size in any particular country, but more particularly in relation to the surge of exploration activity that has occurred in various countries in recent years. This surge was very largely due to the substantial but short-lived jump in world tantalum prices from late 2000 to early 2001. It is likely that the increased tantalum exploration over this period has provided valuable information that has contributed to a much more accurate picture of global tantalum resources.

Canada, Alaska, and Greenland

During the above mentioned period, the most rapid increase in tantalum exploration occurred in Canada, Alaska, and Greenland, with the most intense area of exploration being centred on granitic rare-metal pegmatites intruding Archaean greenstones in the central Canadian states of Manitoba and Ontario. Other areas of increased interest included carbonatite-hosted tantalum deposits in British Columbia and Greenland, and syenite- and nepheline syenite-hosted deposits in the Northwest Territories and in Greenland. Locations for the region's tantalum mine, deposits, prospects, and exploration province are shown in Figure 45.

Canada

In recent years, over 30 tantalum deposits and prospects have been subject to intensive exploration. Despite all the intensive exploration programs and good grades obtained at some prospects, to date Canada's original tantalum deposit at Bernic Lake, Manitoba remains as the country's only producing mine. Detailed summaries of the principal Canadian tantalum prospects, deposits, and mine are given in Tables 15–19.

British Columbia

In British Columbia, tantalum mineralization appears to be almost entirely related to carbonatite-style intrusions, with about 10 such deposits or prospects being recorded in mountainous terrain in the southeast of the state.

The two most notable tantalum exploration sites are the Verity–Paradise deposit and Fir prospect, both of which

are about 30 km north-northeast of Blue River in southeastern British Columbia. Here, large carbonatite sill-like structures have intruded Neoproterozoic gneissic metasedimentary rocks. The carbonatites are rich in tantalum–niobium minerals, mainly pyrochlore and ferrocolumbite. The Verity carbonatite has a strike length of 7 km and is up to 70 m thick, whereas the Fir carbonatite is an almost flat-lying body, 400 m long and up to 75 m wide.

Both exploration sites are owned by Commerce Resources Corporation. Inferred resources at the Verity deposit have been estimated at 3.06 Mt at 0.020% Ta₂O₅, 0.065% Nb₂O₅, and 3.2% P₂O₅, whereas the Fir prospect has yielded drillhole grades of up to 0.032% Ta₂O₅ over 8.2 m (McCrea, 2001). Commerce Resources is endeavouring to develop a beneficiation process to extract tantalum and niobium from the pyrochlore mineralization.

A summary of the principal tantalum deposit and prospects in British Columbia is given in Table 15.

Manitoba and Ontario

These central Canadian states have been the focus of the most intensive tantalum exploration programs in the country in recent years, with at least 21 prospects being investigated out of a total of about 30 known granitic rare-metal pegmatites. The main area of interest is in the Kenora region of southwest Ontario, and extending into southeast Manitoba in the area around Bernic Lake. Other areas with considerable potential include the Northern Superior Province of central-eastern Manitoba and extending into Ontario (Fig. 45). This exploration area covering about 20 000 km² contains at least five prospective tantalum-bearing pegmatites. Another underexplored area is the Sachigo Province, an area of about 9000 km² that surrounds the Pakeagama and Pennock Lake tantalum prospects in central-eastern Ontario.

Throughout Manitoba and Ontario, granitic rare-metal pegmatites are generally hosted by Archaean meta-sedimentary and metavolcanic rocks of the Kenoran greenstone belts, and are situated in close proximity to numerous peraluminous granites of late Archaean age (2650–2550 Ma; Manitoba Geological Survey, 2002). Pegmatite emplacement is usually controlled by zones of structural weakness such as shear zones. Pegmatites may occur individually, in swarms, or occasionally as stacked

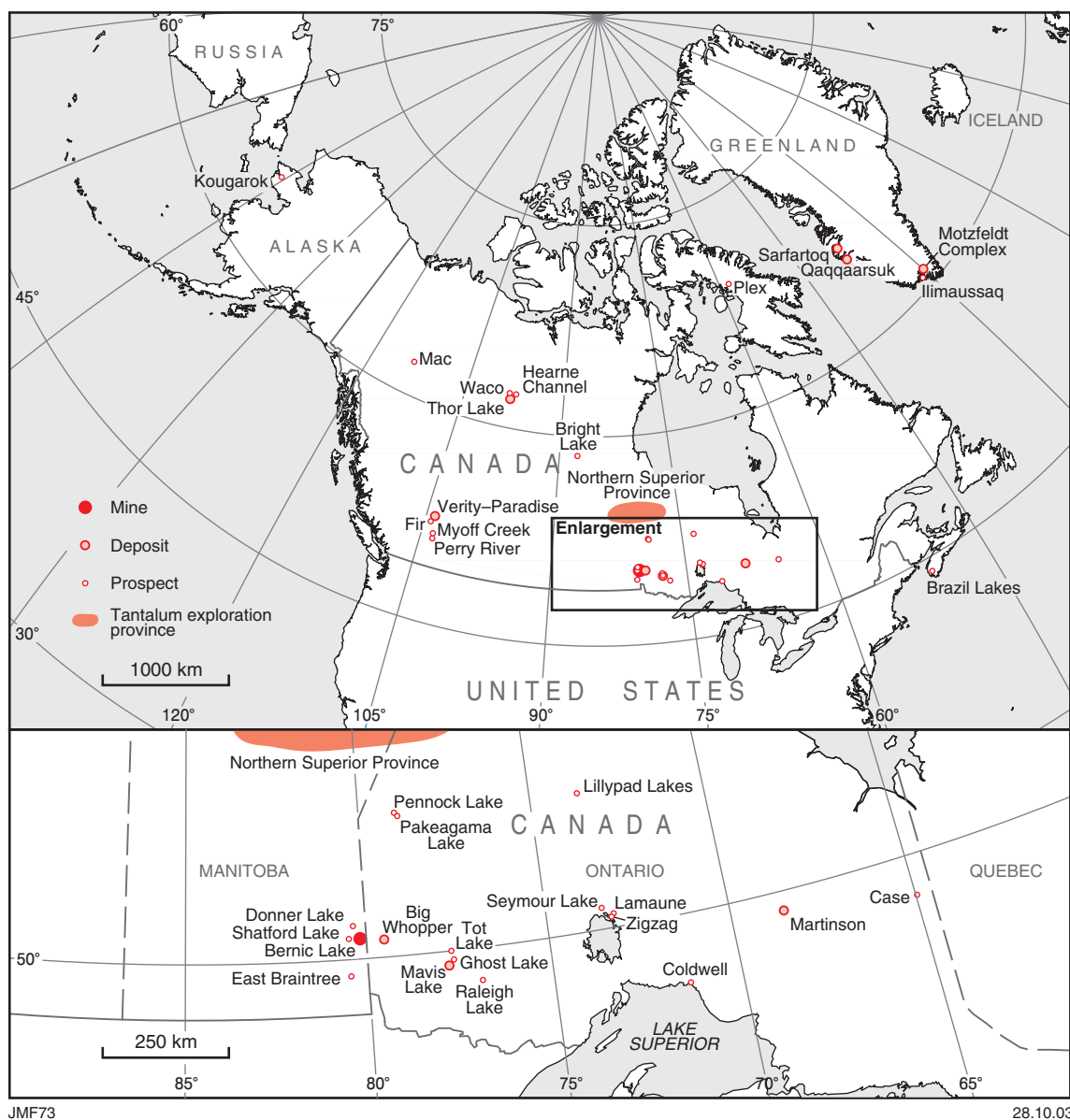


Figure 45. Tantalum mining operations, deposits, prospects, and exploration province in Canada, Alaska, and Greenland

sheets. Discrete associations of mineral assemblages within these pegmatites tend to match Cerny's classification given in Table 8. In general, regional zonation increases with the textural complexity of the pegmatites. As distance from host granites increases, pegmatites tend to exhibit progressive fractionation and rare-element enrichment, often resulting in complex internal zonation patterns.

Many deposits are rich in a wide range of minerals including tantalum–niobium, lithium, caesium, and rubidium. A number of bodies consist of dyke-like pegmatites rich in pollucite (a caesium mineral) or rubellite (a form of tourmaline) and contain high tantalum values commonly of the order of 0.036 – 0.050% Ta_2O_5 . The Lillypad Lakes tantalum–caesium prospect in north-central Ontario is a good example of this type. Average

Ta_2O_5 grades for the region of about 0.030 – 0.040% (obtained from drilling or grab sampling) appear to be on a par with many established tantalum deposits around the world. However, since no resource figures have been published for these prospects, it would appear that many may have resources too small for development in the current climate of low tantalum prices.

Apart from the dominant granitic rare-metal pegmatites in the region, there are two other types of tantalum deposit under investigation. The first of these is the Coldwell peralkaline granite–syenite–metasomatite prospect in central-southern Ontario. In this prospect, tantalum mineralization occurs in altered syenites of the Proterozoic Coldwell Alkaline Intrusive Complex. Tantalum minerals include aeschynite, columbite–tantalite, and pyrochlore, with grab-sample values of 0.03% Ta_2O_5 being recovered.

Table 15. Significant tantalum mineralization in British Columbia, Canada

Mine/deposit/prospect	Location/site	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Fir prospect	25 km north-northeast of Blue River	Commerce Resources	Carbonatite	Ferrocolumbite, pyrochlore	Apatite, richterite, U enrichment	Beforsite	Drillhole grades over 8.2 m: 0.032% Ta ₂ O ₅ , 0.140% Nb ₂ O ₅ , 3.15% P ₂ O ₅
Myoff Creek prospect	55 km northwest of Revelstoke	Cross Lake Minerals	Carbonatite	Niobium and tantalum mineralization	REE enrichment	Carbonatite	0.137% Nb ₂ O ₅ , 0.0034% Ta ₂ O ₅ (channel samples)
Perry River prospect	30 km northwest of Revelstoke	Commerce Resources	Carbonatite	Columbite–tantallite, pyrochlore	Apatite, molybdenite, pyrite, sphalerite, chalcopyrite, monazite, REE enrichment	Sovite	Not available
Verity–Paradise deposit	35 km north-northeast of Blue River	Commerce Resources	Carbonatite	Pyrochlore, ferrocolumbite, fersmite	Apatite, magnetite, vermiculite; REE, U, and Zr enrichment	Beforsite, sovite	Inferred resources: 3.06 Mt at 0.020% Ta ₂ O ₅ , 0.065% Nb ₂ O ₅ , 3.2% P ₂ O ₅

SOURCES: Pell and Hora (1990); Commerce Resources Corp. (2002)

The Martinson carbonatite deposit is located in central-eastern Ontario. With resources of 113 Mt averaging 21.4% P₂O₅, it was intended that this deposit would be developed as a phosphate fertilizer resource in future years. However, it has been reported that the deposit contains a zone with significant concentrations of Nb₂O₅ and Ta₂O₅ (The Northern Miner, 2001).

A summary of the principal tantalum prospects, deposits, and mining activities in Manitoba and Ontario is given in Tables 16 and 17.

Bernic Lake tantalum–lithium–caesium mine

At Bernic Lake in southeast Manitoba, an extensive pegmatite has intruded Archaean metasedimentary and metavolcanic rocks of the Bird River greenstone belt. At this location, the Tantalum Mining Corp. of Canada Limited (TANCO), a wholly owned subsidiary of the Cabot Corporation, operates Canada's only tantalum–lithium–caesium mining operation. The mine was originally established in 1929 as a short-lived operation to mine and process tin from the local area. However, it was not until 1969 that the mine resumed operations as a tantalum mine. Fully fledged operations only began in 1984 when TANCO began to mine its spodumene resource for lithium, which today is its major product together with tantalum, caesium, and rubidium ores that are present in discrete zones.

The shallow underground mine, accessed by a 20° decline, is mined by room and pillar method. The mine has a complex mineralogy with over 80 minerals present. Major minerals include spodumene, amblygonite, wodginite, microlite, pollucite, lepidolite, and K-feldspars. Underground mining operations are shown in Figure 46.

In 2001, the Bernic Lake operation produced about 94 t of Ta₂O₅ concentrate, up about 35% on the previous year's production of about 70 t (Cunningham, 2001).

Northwest Territories

There are four tantalum exploration sites in the Northwest Territories. Three of these are located in the Yellowknife area of the Great Slave Lake region.

The site that has attracted the most attention in recent years is the Thor Lake deposit, about 60 km southeast of Yellowknife. This peralkaline granite–syenite–metasomatite-style deposit is one of five mineralized zones forming part of the Blatchford Lake Alkaline Complex. The mineralization is hosted in an altered syenitic pegmatite – nepheline syenite body thought to be a late-stage derivative of the alkaline complex.

Previous exploration by Placer Development outlined an indicated resource of 70 Mt at 0.03% Ta₂O₅ and 0.4% Nb₂O₅ at Thor Lake. The deposit is currently under investigation by Navigator Exploration Corp. The tantalum mineralization in this deposit was originally found to be too fine-grained to be concentrated by conventional gravity-separation techniques. Navigator is investigating a newly developed flotation process that has the potential to produce good recoveries of high-grade tantalum concentrate.

Table 16. Significant tantalum mineralization in Manitoba, Canada

<i>Mine/deposit/prospect</i>	<i>Location/site</i>	<i>Exploration/mining company</i>	<i>Deposit style</i>	<i>Tantalum minerals</i>	<i>Other minerals</i>	<i>Host rock</i>	<i>Reserves/resources/grades</i>
Bernic Lake mine	180 km east-northeast of Winnipeg	Tantalum Mining Corp. of Canada (TANCO)	Granitic rare-metal pegmatite	Columbite–tantalite group, ferrotapiolite, wodginite group, ixiolite group, strüverite, microlite, simpsonite	Spodumene, amblygonite, pollucite, lepidolite, K-feldspar, cassiterite; Be, Rb, and Ga enrichment	Pegmatite	Reserves pre-production (1991): 2.1 Mt at 0.216% Ta ₂ O ₅ and 7.3 Mt at 2.76% Li ₂ O
Donner Lake prospect	25 km north-northwest of the TANCO mine, Bernic Lake	Kermode Resources	Granitic rare-metal pegmatite	Columbite–tantalite group, ferrotapiolite, wodginite group, ixiolite group, strüverite, microlite, simpsonite	Li, Rb, and Cs enrichment	Pegmatite	Ta ₂ O ₅ grades: Main Dyke: <0.067% South Dyke: 0.025 – 0.055% (grab samples)
East Braintree prospect	130 km east of Winnipeg	Avalon Ventures	Granitic rare-metal pegmatite	Tantalum oxide minerals	Cleavelandite (albite), lepidolite, tourmaline, Cs and Rb enrichment	Pegmatite	Ta ₂ O ₅ grades from 0.029% over 44 m to 0.051% over 1.65 m
Northern Superior Province prospects: Cross Lake, Gods Lake, Red Cross Lake, Red Sucker Lake, Ponask Lake	Manitoba–Ontario, 520–600 km north-northeast of Winnipeg		Granitic rare-metal pegmatite	Columbite–tantalite group, wodginite, microlite	Albite, spodumene, tourmaline, purpurite, petalite, beryl, apatite, pollucite, amblygonite, molybdenite, bismuthinite, lepidolite, zinnwaldite, cassiterite	Pegmatite	Not available
Shatford Lake prospect	6 km southwest of Bernic Lake	Avalon Ventures	Granitic rare-metal pegmatite	Columbite–tantalite group, ferrotapiolite, wodginite group, ixiolite group, strüverite, microlite, simpsonite	Li, Cs, and Rb enrichment	Pegmatite	Not available

SOURCES: Manitoba Geological Survey (2002); Avalon Ventures Ltd (2002b); Kermode Resources Ltd (2002)

Table 17. Significant tantalum mineralization in Ontario, Canada

<i>Mine/deposit/prospect</i>	<i>Location/site</i>	<i>Exploration/mining company</i>	<i>Deposit style</i>	<i>Tantalum minerals</i>	<i>Other minerals</i>	<i>Host rock</i>	<i>Reserves/resources/grades</i>
Big Whopper deposit	Separation Lake, 60 km north of Kenora	Avalon Ventures	Granitic rare-metal pegmatite	Columbite–tantalite (secondary ore)	Li-feldspars and petalite (primary ore), lepidolite, Rb enrichment, spodumene, cassiterite, spessartine	Pegmatite intruding mafic metavolcanic rocks	Indicated and inferred resources: 13.8 Mt at 1.34% Li ₂ O, 0.34% Rb ₂ O, and 0.007% Ta ₂ O ₅
Case prospect	75 km east of Cochrane	Platinova A/S	Granitic rare-metal pegmatite	Columbite–tantalite	Not available	Pegmatite	Ta ₂ O ₅ grades: 0.024% over 8.8 m to 0.035% over 4.5 m
Coldwell prospect	Near Marathon	Avalon Ventures	Peralkaline granite/syenite/metasomatite	Pyrochlore, columbite–tantalite, aeschynite	Rutile, bastnaesite, and other REE minerals	Pegmatite and altered syenite	Ta ₂ O ₅ grade: 0.03% (grab samples)
Ghost Lake prospect	11 km north-northeast of Dryden	Houston Lake Mining	Granitic rare-metal pegmatite	Unspecified tantalum mineralization	Lithium and tin mineralization, tourmaline	Pegmatite	0.019% Ta ₂ O ₅ , 0.012% Sn
Lamaune prospect	220 km north-northeast of Thunder Bay	Platinova A/S	Granitic rare-metal pegmatite	Unspecified tantalum mineralization	Lithium mineralization	Pegmatite	Ta ₂ O ₅ grade (average): 0.021%
Lillypad Lakes prospect	150 km northeast of Pickle Lake	Avalon Ventures	Granitic rare-metal pegmatite	Microlite	Pollucite, rubellite (tourmaline)	Pegmatite (Cs enriched) intruding mafic volcanics	Ta ₂ O ₅ grades: 0.036% over 24.0 m to 0.05% over 8.0 m
Martinson deposit	Near Hearst	MCK Mining Corporation	Carbonatite	Significant Ta–Nb secondary mineralization	Apatite, magnetite	Carbonatite	Resources: 113 Mt at 21.4% P ₂ O ₅
Mavis Lake deposit	10 km east of Dryden	New Claymore Resources	Granitic rare-metal pegmatite	Unspecified tantalum mineralization	Lithium mineralization; Be, W, and Cs enrichment	Pegmatite	Resources: 0.5 Mt LiO ₂
Pakeagama Lake prospect	170 km north of Red Lake	Houston Lake Mining	Granitic rare-metal pegmatite	Columbite–tantalite group, ferrotapiolite, stibiotantalite, wodginitite, microlite	Cassiterite, lepidolite, spodumene, pollucite, tourmaline	Pegmatite (Cs, Rb, and Li enriched)	Ta ₂ O ₅ grade: 0.034% over 11 m (channel sample)
Pennock Lake prospect	185 km north of Red Lake	Kermode Resources	Granitic rare-metal pegmatite	Unspecified tantalum mineralization	Lithium mineralization	Pegmatite	Not available
Raleigh Lake prospect	20 km east of Ignace	Avalon Ventures	Granitic rare-metal pegmatite	Columbite–tantalite group, microlite	Li, Rb, and Cs enrichment	Pegmatite intruding mafic metavolcanic rocks	Ta ₂ O ₅ grades: 0.011% over 5.4 m to 0.027% over 2.0 m

Table 17. (continued)

Mine/deposit/prospect	Location/site	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Seymour Lake prospect	45 km northeast of Armstrong	Linear Resources	Granitic rare-metal pegmatite	Columbite–tantalite	Spodumene, lepidolite, beryl, albite; Rb and Cs enrichment	Pegmatite	Ta ₂ O ₅ average grades: 0.037% over 13.4 m (2 drillholes), 0.043% (>50 channel samples)
Tot Lake prospect	33 km northeast of Dryden	Platinova A/S	Granitic rare-metal pegmatite	Unspecified tantalum mineralization	Lepidolite, Cs enrichment, garnet	Pegmatite intruding metavolcanic rocks	Ta ₂ O ₅ grade: 0.036% over 4.1 m
Zigzag prospect	55 km east of Armstrong	Platinova A/S	Granitic rare-metal pegmatite	Unspecified tantalum mineralization	Lithium mineralization	Pegmatite	Ta ₂ O ₅ grades: 0.37% over 1.0 m; 0.05% over 8.4 m (channel samples)

SOURCES: Avalon Ventures Ltd (2002a); Houston Lake Mining Inc. (2002); Linear Resources Inc. (2002); Platinova A/S (2002a)



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Figure 46. Underground operations at the TANCO tantalum–lithium–caesium mine at Bernic Lake, Manitoba (photo courtesy Sons of Gwalia Ltd)

Another company, Platinova A/S, is currently exploring a block adjacent to Navigator's Thor Lake property.

Elsewhere in the Yellowknife area are two granitic rare-metal pegmatite tantalum prospects. About 100 km east of Yellowknife, Navigator are investigating the Hearne Channel prospect where fractionated pegmatite dykes have yielded grab samples ranging from 0.07 to 1.30% Ta₂O₅. At Waco, 50 km east of Yellowknife, Platinova A/S is investigating a tantalum-bearing pegmatite swarm.

In the remote Mackenzie Mountains located in the eastern Northwest Territories, the War Eagle Mining Company is investigating the Mac prospect that comprises about 25 pegmatite bodies forming part of the Little Nahanni Pegmatite Group, an albite–spodumene dyke complex that intrudes Proterozoic metasediments of the Selwyn Basin. The Mac prospect pegmatites form a discrete swarm within a 200 m-wide zone extending over a strike length of about 5.5 km. Grab samples from the central part of the dyke system have yielded 0.053 – 0.080% Ta₂O₅ and 1.82 – 2.15% Sn.

A summary of the principal tantalum deposit and prospects in the Northwest Territories is given in Table 18.

Nova Scotia, Saskatchewan, and Nunavut Territory

There is one granitic rare-metal pegmatite prospect reported from each of these widely scattered states. The

Table 18. Significant tantalum mineralization in the Northwest Territories, Canada

Mine/deposit/prospect	Location/site	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Hearne Channel prospect	100 km east of Yellowknife	Navigator Exploration Corp.	Granitic rare-metal pegmatite	Mineralization style similar to Bernic Lake	–	Pegmatite	Ta ₂ O ₅ grades: 0.07 – 1.3% (grab samples)
Mac prospect	250 km north of Watson Lake (B.C.)	War Eagle Mining/Strategic Metals	Granitic rare-metal pegmatite	Columbite–tantalite, stüverite	Cassiterite, spodumene, albite, K-feldspar	Pegmatite	Ta ₂ O ₅ grades: 0.053% – 0.080%; 1.82 – 2.15% Sn (grab samples)
Thor Lake deposit	60 km southeast of Yellowknife	Navigator Exploration Corp. (Platinova A/S exploring on adjacent property)	Peralkaline granite/syenite/metamatite	Unspecified tantalum and niobium mineralization	Zr and REE enrichment, nepheline	Syenitic pegmatite/syenite	Indicated resources: 70 Mt at 0.03% Ta ₂ O ₅ and 0.4% Nb ₂ O ₅
Waco prospect	50 km east of Yellowknife	Platinova A/S	?Granitic rare-metal pegmatite	Tantalite	–	Pegmatite	Not available

SOURCES: Navigator Exploration Corp. (2002a); Platinova A/S (2002b)

most interesting of these properties is the Plex prospect located on remote Baffin Island in the Nunavit Territory. Platinova A/S is currently reinvestigating a series of zoned rare-metal pegmatites containing columbite–tantalite that were originally examined in 1980 by Cominco. At that time Cominco reported high tantalum values associated with muscovite-rich segregations in various internal pegmatite zones. A summary of the principal tantalum deposit and prospects in these states is given in Table 19.

Alaska

Currently, Alaska is the only state of the USA with significant tantalum mineralization. The Kougarok prospect is situated on the Seward Peninsula in western Alaska, about 112 km north-northeast of Nome. This prospect is a rare-metal (Li–F) granite similar to the Yichun rare-metal apogranite tantalum deposit in China (see **China** later in this chapter). The Kougarok prospect comprises a tabular lithium–fluorine granite plug buried 200–400 m below the surface. The plug, which is 100–150 m thick with a surface area of about 1.2 × 1.0 km, may have been the feeder system to an overlying magmatic–hydrothermal system containing tin–tantalum mineralized greisens, the target of the present exploration program.

The deposit is being jointly explored by Navigator Exploration Corp. and Chapleau Resources. Drillhole results have returned grades up to 0.043% Ta₂O₅ over 31.5 m. The Kougarok prospect is summarized in Table 20.

Greenland

There are four significant tantalum deposits located in western and southern Greenland. The Qaqaarsuk and Sarfartoq deposits in western Greenland, operated by New Millenium Resources, are niobium-rich carbonatite deposits with pyrochlore being the potential ore-bearing mineral. Whereas Qaqaarsuk contains only minor Ta₂O₅ grades, Sarfartoq has returned some high-value drill intersections for Ta₂O₅ such as 0.146% over 9.0 m.

The Ilimaussaq alkali intrusion (8 × 17 km in size) in southern Greenland, also owned by New Millenium Resources, is an agpaite nepheline syenite deposit with zircon (0.8 Mt at 6% ZrO₂), rare earths (0.2 Mt at 3% REE), and yttrium oxide (39 000 t at 0.2% Y₂O₅) being the target mineral ores. Tantalum analyses have returned 0.040% Ta.

The deposit with the greatest potential for tantalum in Greenland is situated in the Motzfeldt Complex, in southern Greenland. The deposit is currently being evaluated by Angus & Ross. The Motzfeldt Complex is a major alkaline structure covering an area of 300 km² within the Gardar Rift. The main igneous phase of the complex is a ring structure of largely concentric, outward and steeply dipping units mainly composed of peralkaline syenite and nepheline syenite. The oldest outer ring contains the tantalum–niobium mineralization. Tantalum is present in the mineral pyrochlore in which the Ta

Table 19. Significant tantalum mineralization in Nova Scotia, Saskatchewan, and Nunavit Territory, Canada

<i>Mine/deposit/prospect</i>	<i>Location/site</i>	<i>Exploration/mining company</i>	<i>Deposit style</i>	<i>Tantalum minerals</i>	<i>Other minerals</i>	<i>Host rock</i>	<i>Reserves/resources/grades</i>
Brazil Lakes prospect	Nova Scotia, 25 km northeast of Yarmouth	Waseco Resources	Granitic rare-metal pegmatite	Columbite–tantalite	Spodumene, cassiterite, beryl, albite, zircon, microcline, Rb enrichment	Pegmatite intruding amphibolite and quartzite	Ta ₂ O ₅ grades: 0.014% over 6.19 m to 0.011% over 8.44 m
Bright Lake prospect	North-central Saskatchewan	Leader Mining International	Granitic rare-metal pegmatite	Unspecified tantalum mineralization	Li, Rb, and Cs enrichment	Pegmatite	0.0147% Ta ₂ O ₅ , 0.070% Sn (grab samples)
Plex prospect	Nunavit Territory, Baffin Island, 350 km east of Hall Beach	Platinova A/S	Granitic rare-metal pegmatite	Columbite–tantalite	Muscovite	Pegmatite	Not available

SOURCE: Platinova A/S (2002c)

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Table 20. Significant tantalum mineralization in Alaska, USA

<i>Mine/deposit/prospect</i>	<i>Location/site</i>	<i>Exploration/mining company</i>	<i>Deposit style</i>	<i>Tantalum minerals</i>	<i>Other minerals</i>	<i>Host rock</i>	<i>Reserves/resources/grades</i>
Kougarok prospect	Seward Peninsula, 112 km north-northeast of Nome	Navigator Exploration Corp./Chapleau Resources	Rare-metal (Li–F) granite	Columbite–tantalite, ?microlite	Cassiterite, albite, zinnwaldite, ?lepidolite, pyrrhotite, arsenopyrite, wolframite, fluorite, Bi and Ag enrichment	Albitized and greisenized granite	Ta ₂ O ₅ grades: 0.024% over 115.1 m to 0.043% over 31.5 m

SOURCE: Navigator Exploration Corp. (2002b)

concentration level ranges from 1.3 to 1.8%, and the Ta:Nb ratio varies from 1:8 to 1:50. The Ta:Nb ratio also varies vertically in the deposit, with the highest tantalum values occurring towards the base. Ta:Nb ratios are usually higher in altered syenites compared to peralkaline microsyenites.

Inferred resources at Motzfeldt were originally estimated at 50 Mt at 0.03 – 0.10% Ta₂O₅ and 130 Mt at 0.04 – 1.00% Nb₂O₅. However, recent exploration by Angus & Ross in 2001 at Locality 4 within the Motzfeldt Complex has located enriched pyrochlore zones in an altered syenite unit, resulting in preliminary estimates of a high-grade resource of 15 Mt at greater than 0.050% Ta₂O₅ and 0.600% Nb₂O₅, plus a lower grade resource of more than 20 Mt at greater than 0.030% Ta₂O₅ and 0.400% Nb₂O₅. The company is also evaluating methods of producing a concentrate of about 35% Ta₂O₅ and Nb₂O₅ at a 65% recovery rate from the high-grade ore (Angus & Ross plc, 2002c).

A summary of the principal tantalum deposits in Greenland is given in Table 21.

Africa

Tantalum mineralization has been reported from at least 17 countries in Africa. Central African countries such as the Democratic Republic of the Congo, Uganda, Burundi, and Rwanda have been significant suppliers of tantalum concentrates for at least 40 years, with all production from alluvial and eluvial deposits produced by artisanal mining groups and prospectors. Other countries producing significant quantities of tantalum include Nigeria, Ethiopia, and Zimbabwe. Mining operations were recently started in Namibia and Mozambique. Minor tantalum production has been reported from countries such as Zambia, Gabon, South Africa, Niger, and the Ivory Coast; however, details relating to deposits and production levels are extremely limited.

Recently an Australian company, Gippsland Limited, identified a 40 Mt tantalite deposit at Abu Dabab in Egypt's Eastern Desert (Gippsland Limited, 2002a). Deposits of tantalum, niobium, tin, and tungsten have also been discovered in the Tibesti Mountains of northern Chad.

Over most of Africa, almost all known tantalum deposits and prospects appear to be related to granitic rare-metal pegmatites or their regolith derivatives, such as deeply weathered deposits formed in situ, or transported eluvial and alluvial placer deposits. The few exceptions to this are tantalum mineralization within rare-metal apogranite intrusions in the area around Abu Dabab in Egypt, and in peralkaline granites in several areas of central Nigeria.

Throughout western, central, and southern Africa there are numerous intrusions of younger phase late Archaean or early Palaeoproterozoic granites, similar to younger Archaean granite suites in cratonic areas of Western Australia and central Canada. In many places, late-phase rare-metal pegmatites, ranging from individual bodies to

extensive swarms, emanated from these granitic bodies to intrude schists and gneisses of older greenstones.

A summary of the principal tantalum mines, deposits, and prospects in Africa is given in Table 22 and their locations are shown in Figure 47.

Democratic Republic of Congo

Tantalum mineralization is widespread throughout the eastern part of the Democratic Republic of Congo (DRC), being found in Kivu, Maniema, Orientale, and Katanga Provinces. In these areas there are extensive, thick eluvial and alluvial placer deposits of columbite–tantalite (known locally as 'coltan' and containing 10–40% Ta₂O₅) and also cassiterite. For over 40 years, coltan deposits in the region have been mined by artisanal family mining groups and prospectors, with the main centre for collection and distribution being the town of Goma on the country's eastern boundary with Rwanda. The DRC is currently the largest tantalum producer in Africa.

With the outbreak of the second Congolese war in 1998, mining, distribution and sale of coltan came under the control of the Rwandan-backed rebel army holding power in eastern DRC. During 2000 coltan mine production peaked at 130 t, but by 2001 had dropped back to 60 t (Cunningham, 2002). This situation continued for over three years until the withdrawal of the rebel army in mid-2002. It appears that the mining situation in the DRC is now stabilizing despite prevailing low world tantalum prices.

Egypt

In late 2001, Gippsland Limited identified three rare-metal (Li–F) tantalum–tin granite deposits in the Eastern Desert region of Egypt, about 75 km south of the seaport of Quseir. The deposits are hosted in small apogranite stocks up to 400 m in diameter. Estimated Ta₂O₅ resources are Abu Dabab with 39.9 Mt at 0.025%, El Nuweiba with 83 Mt at 0.016%, and Umm Naggat with 25 Mt at 0.015% (Egyptian Geological Survey and Mining Authority, 2002).

The company, which has a 50% joint venture agreement with the Egyptian Government in this project, is currently focusing its attention on the Abu Dabab deposit, with the objective of bringing the project into production in 2004. To buffer against further volatility in the current price of tantalum, the company is also considering producing high-grade feldspar for the ceramic industry from the deposit. It has been estimated that about 0.5 Mtpa of albite and microcline feldspar could be produced in addition to tantalite ore (Industrial Minerals, 2002a).

Ethiopia

Ethiopia is the second largest producer of tantalum in Africa. All production comes from the Kenticha mine, owned by Midroc Ethiopia, about 300 km south of Addis Ababa. The mine produces tantalite ore from deeply weathered pegmatite regolith overlying the rare-metal

Table 21. Significant tantalum mineralization in Greenland

<i>Mine/deposit/ prospect</i>	<i>Location/site</i>	<i>Exploration/mining company</i>	<i>Deposit style</i>	<i>Tantalum minerals</i>	<i>Other minerals</i>	<i>Host rock</i>	<i>Reserves/resources/grades</i>
Ilimaussaq deposit	South Greenland, 50 km southwest of Narsarsuaq International Airport	New Millennium Resources	Agpaitic nepheline syenite	Unspecified Nb–Ta mineralization	Zircon, REE, sodalite; Y, Hf, Be, U enrichment	Nepheline syenite	Estimated resources: 0.8 Mt at 6% ZrO ₂ , 0.2 Mt at 3% REE, 39 000 t at 0.2% Y ₂ O ₃ , 0.040% Ta, 0.100% Hf
Motzfeldt Complex deposit	South Greenland, 25 km east of Narsarsuaq International Airport	Angus & Ross	Peralkaline granite/syenite/metasomatite	Pyrochlore	Thorite, zircon, bastnaesite; REE, U, Th, Mo enrichment	Syenite, nepheline syenite	Inferred resources: 50 Mt at 0.03 – 0.1% Ta ₂ O ₅ , 130 Mt at 0.04 – 1.0% Nb ₂ O ₅
Qaqqarsuk deposit	West Greenland, 160 km north-northwest of Nuuk	New Millennium Resources	Carbonatite	Pyrochlore and betafite (niobium ore with Ta enrichment)	REE enrichment	Carbonatite (sovite), glimmerite, fenite	Indicated resource: 3.5 Mt at 0.5% Nb ₂ O ₅
Sarfartoq deposit	West Greenland, 270 km north-northwest of Nuuk	New Millennium Resources	Carbonatite	Pyrochlore in high-grade niobium-rich ring dykes	–	Carbonatite	Indicated niobium resource: 0.1 Mt at 4.6% Nb ₂ O ₅ . Drill intersections: 19.6% Nb ₂ O ₅ and 0.146% Ta ₂ O ₅ over 9 m

SOURCES: Angus & Ross plc (2002c); New Millennium Resources NL (2002)

Table 22. Significant tantalum mineralization in Africa

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Burundi and Rwanda							
Kigali region, Rwanda	Numerous small deposits and workings	Small cooperatives and artisanal miners	Probably placer	Columbite–tantalite ('coltan')	–	?Stream sediments	Not available
Democratic Republic of Congo							
Kivu, Maniema, Orientale, Katanga provinces	Numerous eluvial and alluvial deposits and workings	Artisanal miners	Placer	Columbite–tantalite ('coltan')	Cassiterite	Soil and stream sediments	Not available
Egypt							
Eastern Desert, 65–90 km south of Quseir (Red Sea)	Abu Dabab deposit	Gippsland Ltd (50%) Egyptian Govt (50%)	Rare-metal (Li–F) granite	Columbite–tantalite	Cassiterite, Na/K-feldspar, tungsten mineralization	Granite	Total resources of 39.9 Mt at: 0.025% Ta ₂ O ₅ , 0.012% Nb ₂ O ₅ , 0.089% Sn, 0.48 Mt feldspar.
	El Nuweiba deposit		Rare-metal (Li–F) granite	Columbite–tantalite	Tin, tungsten mineralization	Granite	Ta ₂ O ₅ reserves: 83 Mt at 0.0156%.
	Umm Naggat deposit		Rare-metal (Li–F) granite	Columbite–tantalite	Tin, tungsten mineralization	Granite	Ta ₂ O ₅ reserves: 25 Mt at 0.0151%
Equatorial Guinea							
Rio Muni, Acocseng area, 150 km southeast of Bata	Aconibe prospect		Placer, granitic rare-metal pegmatite	Columbite–tantalite	–	Soil, alluvium, pegmatite	Columbite–tantalite placer grades: 3.0–7.5 kg/m ³
	Ayamiken prospect		Placer, granitic rare-metal pegmatite	Columbite–tantalite	–	Soil, alluvium, pegmatite	Not available
Ethiopia							
300 km south of Addis Ababa	Kenticha mine	Midroc Ethiopia	Mineralized, deeply weathered regolith over granitic rare-metal pegmatite	Columbite–tantalite	Quartz, feldspar, kaolin	Regolith materials, pegmatite	Proven low-grade reserves of 116 Mt
Ghana							
100 km northwest of Accra	Akim-Oda prospect	Leo Shield Exploration	Placer derived from granitic rare-metal pegmatite	Columbite–tantalite	–	Stream sediments	Not available
	Anamase prospect				–	–	Not available

Table 22. (continued)

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Mozambique Zambezia Province, Alto Ligonha region	Morrua deposit	Cabot Corporation joint venture	Granitic rare- metal pegmatite	–	Quartz, beryl, tourmaline, topaz, kaolin, Cs and Li enrichment	Pegmatite	Reserves: 7.5 Mt at 0.07% Ta ₂ O ₅
	Muriane deposit		Granitic rare- metal pegmatite	Columbite–?tantallite	Quartz, beryl, tourmaline, topaz, kaolin, Cs and Li enrichment	Pegmatite	7.0 Mt at 0.016% Ta ₂ O ₅ (pre-production)
	Marropino deposit		Mineralized, deeply weathered regolith over granitic rare- metal pegmatite	Columbite–?tantallite	Quartz, beryl, tourmaline, topaz, kaolin, Cs and Li enrichment	Regolith materials, pegmatite	21.7 Mt at 0.019% Ta ₂ O ₅
Namibia 25 km south of Warmbad 220 km west- northwest of Windhoek 250 km northwest of Windhoek Uis area, 290 km northwest of Windhoek Uis area, 290 km northwest of Windhoek Uis area, 290 km northwest of Windhoek Strathmore area, 334 km west-northwest of Windhoek	Tantalite Valley mine	Tantalite Valley Mining	Granitic rare- metal pegmatite	Columbite–tantallite	Lithium and bismuth mineraliza- tion, beryl, mica	Pegmatite	Reserves and resources: 0.74 Mt at 0.043% Ta ₂ O ₅
	Sandamap prospect (Erongo area)	Reefton Mining	Granitic rare- metal pegmatite, placer	Columbite–tantallite	Cassiterite, lithium mineralization, tourmaline	Pegmatite	0.021% Ta ₂ O ₅ (composite drilling samples) and up to 0.045% Ta ₂ O ₅ (soil samples)
	Nainais–Kohero prospect	Rusina Mining and Reefton Mining	Granitic rare- metal pegmatite	Columbite–tantallite	Cassiterite	Pegmatite in cassiterite schist	Not available
	Three Aloes mine	Central African Mining & Exploration, artisanal miners	Granitic rare- metal pegmatite, placer	Columbite–tantallite	Cassiterite	Pegmatite, alluvial and eluvial material	Resources: 7.2 Mt at about 0.05% Ta ₂ O ₅
	B1 and C1 Pegmatites prospects	Central African Mining & Exploration, artisanal miners	Granitic rare- metal pegmatite	Columbite–tantallite	Cassiterite	Pegmatite	Resources: 2.0 Mt at 0.024% Ta ₂ O ₅ , 0.094% SnO ₂
	Uis slimes dam mine	Central African Mining & Exploration	Reprocessing of tin–tantalum dumps	Columbite–tantallite	Cassiterite	–	Resources: 4 Mt at 0.006% Ta ₂ O ₅ , 0.053% Nb ₂ O ₅ , 0.33% SnO ₂
	Numerous prospects and small mines	Central African Mining & Exploration, artisanal miners	Granitic rare- metal pegmatite, placer	Columbite–tantallite	Cassiterite, petalite, beryl, mica	Numerous pegmatites and ?stream sediments	Not available

Table 22. (continued)

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Nigeria							
Jos Plateau, central Nigeria, especially around Jos and Nasarawa	Numerous small deposits and workings	Mainly artisanal miners	Granitic rare-metal pegmatite, peralkaline granite/syenite/metasomatite, placer	Columbite–tantalite	Cassiterite	Pegmatite, stream sediments	Not available
Nasarawa region, 500 km east-northeast of Lagos	Numerous prospects and workings	Columbia River Resources, artisanal miners	Granitic rare-metal pegmatite, peralkaline granite/syenite/metasomatite, placer	Columbite–tantalite	Cassiterite	Pegmatite, stream sediments	Ta ₂ O ₅ grades up to 0.035%
Uganda							
Mainly in southwest and northeast Uganda	Numerous small deposits and workings	Mainly artisanal miners	Granitic rare-metal pegmatite, ?placer	Columbite–tantalite, microlite	Beryl	Pegmatite, ?stream sediments	Not available
290 km west-southwest of Kampala	Nyanga prospect	Uganda Gold Mining	Mineralized, deeply weathered regolith over granitic rare-metal pegmatite	Columbite–tantalite	Beryl, cassiterite, quartz	Regolith materials, pegmatite	Average ore grade: 31.54% Ta ₂ O ₅ and 30.56% Nb ₂ O ₅
Zimbabwe							
Mainly in eastern and central western Zimbabwe	Numerous small deposits and workings, especially around Kamativi	Small cooperatives and artisanal miners	Granitic rare-metal pegmatite, mine dumps, placer	Columbite–tantalite	Cassiterite	Pegmatite, stream sediments	Not available
420 km west-southwest of Harare	Kamativi mine	Allied Mining Investments	Reprocessing of tin–tantalum dumps	Columbite–tantalite	Cassiterite	–	Not available
Sutswe area, 170 km north-northeast of Harare	Eagle mine and Donsa mine	Central African Mining & Exploration	Granitic rare-metal pegmatite, regolith	Columbite–tantalite, microlite	Beryl, quartz, spodumene, muscovite, albite, microcline	Pegmatite, eluvial material in soil	Resources: Eagle: 0.61 Mt at 0.034% Ta ₂ O ₅ . Donsa: 1.62 Mt at 0.025% Ta ₂ O ₅
Sutswe area, 170 km northeast of Harare	Dove 14 mine	Central African Mining & Exploration	Granitic rare-metal pegmatite	Columbite–tantalite	Beryl, quartz, muscovite, albite	Pegmatite	Resource: 0.65 Mt at 0.044% Ta ₂ O ₅
Rusambo area, 185 km north-northeast of Harare	Anomalous tantalite prospects	Central African Mining & Exploration	Granitic rare-metal pegmatite, placer	Columbite–tantalite	Beryl	Pegmatite, stream sediments	Not available
Shamva area, 80 km northeast of Harare	Wanroo deposit		?Granitic rare-metal pegmatite	Microlite	–	Pegmatite	0.129 Mt at 0.07% Ta ₂ O ₅

SOURCES: Africa (general) — U.S. Geological Survey (2002); Minmet Ozmine (2002a); MBendi (2002)
 Egypt — Gippsland Ltd (2002b); Egyptian Geological Survey and Mining Authority (2002)
 Namibia and Zimbabwe — Central African Mining and Exploration Co. plc (2002)



Figure 47. Tantalum mining provinces, mining operations, deposits, and prospects in Africa and Saudi Arabia

pegmatite body at depth, and from adjacent eluvial deposits. In 2000 production peaked at about 54.4 tpa. Once mining of the unconsolidated regolith ore has been completed, attention will have to be focused on mining the underlying hard-rock ore. Initial indications are that the hard-rock tantalum resources could be significant, with grades probably about 0.020% Ta₂O₅ and available resources capable of producing between 90 and 226 tpa (Linden, 2000).

Mozambique

In Mozambique, tantalum mineralization is confined to the northwest region of Alto Ligonha in the Zambezia Province. In this region complex, zoned granitic rare-metal

pegmatites have been mined for tantalite for many years and more recently three major deposits have been identified. The first of these is the Morrua deposit, once the largest tantalite producer in Mozambique, with estimated reserves of 7.5 Mt at up to 0.07% Ta₂O₅. This deposit is currently being re-evaluated by the Cabot Corporation in a joint venture arrangement. It is possible that this deposit could be redeveloped to produce 200 tpa of tantalite; however, significant infrastructure costs would be involved. The remaining deposits at Muriane and Marropino are estimated to contain reserves and resources of 7.0 Mt at 0.016% and 21.7 Mt at 0.019% Ta₂O₅ respectively. At Marropino, the central area of the ore zone has been extensively kaolinized by deep weathering to a depth of 50 m.

The recent development of alluvial and eluvial deposits in the Morrua area has led to the establishment of a processing plant that is in operation, with initial production reported to be around 45 tpa with the capacity to increase production up to about 140 tpa (Linden, 2000).

Namibia

In southern Namibia, in an area known as Tantalite Valley, there are numerous granitic rare-metal pegmatites, some as much as 12 km long by 5 km wide. In 2001 the Tantalite Valley mine, with reserves and resources estimated at 0.74 Mt at 0.043% Ta₂O₅, was reopened. This project, owned by Tantalum Valley Mining and expected to process 6000 tonnes/month (tpm) of tantalite ore to produce 1.5 tpm Ta₂O₅, operated for a few months only before closing due to performance problems combined with a sharp drop in the tantalite price (Mining Journal, 2002b).

In recent times in northern Namibia, there has been minor tantalite mining by local artisanal mining groups. There has also been considerable tantalite exploration in this region, particularly in the Uis area, about 290 km northwest of Windhoek. In this area, the Central African Mining and Exploration Company (CAMEC) developed a plan to redevelop old tantalite–tin deposits at the Three Aloes mine, and the B1 and C1 Pegmatites. These deposits are estimated to contain Ta₂O₅ resources of 7.2 Mt at 0.05% and 2.0 Mt at 0.024% respectively (Simmonds et al., 2002).

CAMEC recently acquired a 51% share in ABC Mines and is currently purchasing about 1.5 tpm Ta₂O₅ from the company's AB mine at Uis. CAMEC has also carried out a feasibility study on the reprocessing of tailings from the Uis slime dumps from the old ISCOR tin mine estimated to contain 4 Mt at 0.006% Ta₂O₅, 0.053% Nb₂O₅, and 0.33% tin. To set up this operation, a processing plant would have to be built at Uis to produce about 23 t of Ta₂O₅ and 65 t of tin per annum.

Also in northern Namibia, there are a number of other tantalite exploration areas around granitic rare-metal pegmatites and associated placer prospects. CAMEC is exploring in the Strathmore area, Reef-ton Mining have a prospect at Sandamap, and also at Nainais–Kohero in a joint venture with Rusina Mining.

Nigeria

Large tantalite deposits have been reported in Nigeria, mainly in rare-metal pegmatites and alluvial placer deposits in Nasarawa, Gombe, and the Kogi states, and in the Federal Capital Territory.

In central Nigeria, the mining of coltan has been practised for many years by artisanal mining groups. The areas around Nasarawa and the old tin mining areas of the central Jos Plateau appear to be the main focus of this industry. In these and other areas, coltan is produced by artisanal groups and is accumulated by local traders for

export. For example, it is reported that artisanal workers in the Nasarawa area produce about 35 tpa of coltan, and further north at Kano about 1 t is exported by air transport each month. Linden (2000) stated that Nigerian tantalite production for 2000 was estimated to be about 90 t.

Columbia River Resources have been actively exploring old tantalite workings in areas of extensive pegmatite swarms in central Nigeria (MBendi, 2003). In 2001, the company formed an agreement with Nigeria's only official tantalum producer, Bakuwa Mining Works, to access prospecting and mining licence areas in Nasarawa State. In these properties, Ta₂O₅ grades up to 0.035% have been consistently reported.

Rwanda

The coltan industry in Rwanda comprises small co-operatives and artisanal mining groups in a variety of locations, with the majority situated in an east–west zone about 30 km wide that extends through Kigali. Cunningham (2001) estimated that coltan production in 2001 was about 350 t that contained about 95 t of tantalum.

Zimbabwe

The tantalum industry in Zimbabwe also has a long history of artisanal miners who mine small quantities of tantalite and sell it to local traders who subsequently arrange for its export in bulk lots. In 2000, a rough estimate put total production at about 9.0 tpa (Linden, 2000).

Production is mainly centred around two areas. The first is Kamativi in the far west of the country, about 420 km west-southwest of Harare, and the second is in the country's northeast 100–180 km northeast of Harare in areas around Sutswe, Rusambo, and Shamva.

In March 2001, Allied Mining Investments were seeking US\$7.5 million to reopen the Kamativi tin mine as a tantalum operation, after receiving Government approval to buy and operate the mine. Before closure in 1994, the mine was producing 1200 tpa of tin and about 60 tpa of tantalum concentrates (Carlin, 2001). Since its closure, approximately 82 artisanal mining groups have been known to be scavenging tin–tantalum ore from around the abandoned Kamativi mine site.

Several years ago, in the northeast of the country, CAMEC was intending to prove-up reserves in its properties and set up a 60 tonnes/hour processing plant in the Sutswe area. These properties contain the Eagle, Donsa, and Dove 14 mines, with resources of 0.61 Mt at 0.034% Ta₂O₅, 1.62 Mt at 0.025% Ta₂O₅, and 0.65 Mt at 0.044% Ta₂O₅ respectively. CAMEC also has tantalum prospects at Rusambo in the same region (Simmonds et al., 2002).

At Shamva, about 80 km northeast of Harare, the undeveloped Wanroo deposit is estimated to contain unproven reserves of 0.13 Mt at 0.07% Ta₂O₅.

Asia

Across Asia tantalum provinces, deposits, and prospects are found in eight countries in diverse locations spread throughout the continent, with the main concentration being located in the southeastern mountainous regions of the Russian Federation. Most deposit styles are represented, from the extensive terrestrial and marine alluvial placer deposits of Malaysia, Thailand, and Burma to the more unusual apatitic nepheline syenite-hosted deposits of the Kola Peninsula in the Russian Federation. Notably, granitic rare-metal pegmatites that are so common in many other regions of the world appear to be in a minority in Asia.

Despite the presence of many reportedly large deposits, tantalum production is limited to only a few countries, mainly China, Malaysia, and Thailand, with only very small quantities currently mined in the Russian Federation. However, it should be noted that information relating to the location, geology, mineral resources, and mining activities of many of the Russian Federation tantalum mines and deposits is extremely limited.

A deposit currently attracting some attention is the Ghurayyah tantalite deposit in northwestern Saudi Arabia. Tertiary Minerals plc is carrying out a re-evaluation of this deposit and has recently identified a resource of 385 Mt at 0.025% Ta₂O₅ (Australia's Paydirt, 2002b).

A summary of the principal tantalum mines, deposits, and prospects in Asia is given in Table 23 and their locations are shown in Figures 47 and 48.

China

China has two main tantalum mining areas at Yichun in Jiangxi Province, and at Nanping in Fujian Province, together with the 801 mine in Inner Mongolia that is reportedly coming on-stream in 2003.

In addition, minor tantalum production has been reported from the Ma Ar Kan spodumene mine in Sichuan Province and the Limu tin mine in the south of the country. Tantalum produced as a byproduct in 2000 was estimated at about 11 t (Linden, 2000). Other tantalum–niobium mines are the Shicheng mine in Jiangxi Province, and the Paitan, Taimei, and Yonghan mines in Guandong; however, no details are available about these operations.

Jiangxi Province

The Yichun tantalum–niobium–lithium openpit mine, located 180 km southwest of Nanchang in Jiangxi Province, is China's biggest tantalum producer (over 54 tpa) and accounts for over half of China's output. The deposit is comparatively low grade, with proven reserves of 6800 t at 0.017–0.020% Ta₂O₅. The mine is also a major producer of lithium sourced from lepidolite. Further increases in production are planned, but will require significant investment on new infrastructure to succeed.

The Yichun deposit is regarded as being a model example of the rare-metal (Li–F) granite or apogranite

style of deposit. In this deposit, columbite–tantalite, microlite, and Ta-rich cassiterite are present in the apogranitic body, a small sheet-like body of topaz–lepidolite granite that represents the most fractionated and latest phase of the Jurassic Yanshan batholith. This granite is composed mainly of albite, lepidolite, and quartz, with topaz, K-feldspar, amblygonite, and accessory zircon, monazite, pollucite, and the tantalum minerals mentioned above. The granite overlies an earlier sheet-like Li-mica granite (also containing minor tantalum–niobium mineralization) that in turn overlies the parent muscovite granite that occupies almost 60% of the batholith's outcrop area (Yin et al., 1995).

The mineralized topaz–lepidolite granite is characterized by the presence of a marginal 'stockscheider' that consists of a banded pegmatitic and quartz-rich porphyritic facies enriched with beryl, topaz, and tourmaline. This stockscheider separates the topaz–lepidolite granite from contact with local metasedimentary rocks at the margin of the intrusion.

A geological map and cross section of the Yanshan batholith is shown in Figure 49.

Fujian Province

The Nanping underground mine, located 130 km west-northwest of Fuzhou in Fujian Province, came into production in 2000. The operating company, Ninning Tantalum–Niobium Mining, is a joint venture partly owned by the Ningxia Non-ferrous Metals Smeltery (NNMS). It has been demonstrated that the deposit has proven reserves of 4230 t at 0.030% Ta₂O₅. The plant has been designed to produce up to 116 tpa Ta₂O₅ concentrates. Ta₂O₅ concentrates are shipped to the NNMS in Ningxia Huizu Autonomous Region for the manufacture of tantalum powder (Tse, 1997).

The Nanping tantalum deposit is situated in a large swarm of zoned granitic rare-metal pegmatites clustered around a migmatitic host granite of late Palaeozoic age. Yueqing et al. (1985) identified four distinct pegmatite zones of increasing fractionation and complexity radiating out from the host granite. The outermost zone (type IV) contained significant levels of the rare-metals elements tantalum, niobium, tin, lithium, rubidium, and caesium. Over 80 minerals, including wodginite, were identified in the type IV pegmatites.

Inner Mongolia

The 801 mine is located near Tongliao in eastern Inner Mongolia, about 640 km northeast of Beijing. The current owners are the Ningxia Non-ferrous Metals Smeltery. This mine has large resources of tantalum–niobium, rare earths, and zirconium, and the ore is accessible by open cutting. Proven reserves quoted for the deposit are 6.8 Mt and the average Ta₂O₅ grade in the upper 50 m of the deposit is 0.022%, with niobium values being considerably higher (Ningxia Non-ferrous Metals Smeltery, 2002; China Market, 2002). It was originally estimated that the mine would commence production in 2003 (Linden, 2000).

Table 23. Significant tantalum mineralization in Asia

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
China							
Jiangxi Province, 180 km southwest of Nanchang	Yichun mine	Yichun and Xin Fang mining companies	Rare-metal (Li–F) granite (apogranite)	Columbite–tantalite, microlite, Ta-rich cassiterite	Topaz, lepidolite, zinnwaldite, K-feldspar, albite, fluorite	Topaz–lepidolite granite	Proven reserves: 6 800 t at 0.017 – 0.020% Ta ₂ O ₅
Fujian Province, 130 km west-northwest of Fuzhou	Nanping mine	Ninning Tantalum–Niobium Mining	Granitic rare-metal pegmatite	Columbite–tantalite, tapiolite, wodginite	Cassiterite, beryl, albite, pollucite, lithium, rubidium, and phosphate mineralization	Pegmatite	Proven reserves: 4 230 t at 0.030% Ta ₂ O ₅
Inner Mongolia, Tongliao region, 640 km northeast of Beijing	801 mine	Ningxia Non-ferrous Metals Smeltery	Possibly a peralkaline granite/syenite/metasomatite	Unspecified tantalum mineralization	Beryl, zircon, REE	Not known	Proven reserves: 6.8 Mt. Average grade in upper 50 m of deposit is 0.022% Ta ₂ O ₅
India							
Madhya Pradesh, Surguja district, 550 km east-northeast of Bhopal	Belangi prospect	–	Granitic rare-metal pegmatite, placer	Columbite–tantalite	Beryl, muscovite, microcline, quartz, tourmaline, garnet, magnetite, ilmenite	Pegmatite	Ta ₂ O ₅ grades: 0.008 – 0.032%
Malaysia							
Mainly on west coast in Perak and Selangor	Onshore and offshore tin-dredging and gravel-pump mining operations	(40 tin companies operating in 2000)	Placer, mineralized deeply weathered kaolinitic regolith mainly from rare-metal (Li–F) granites	Columbite–tantalite, strüverite	Cassiterite	Granite, pegmatite, kaolin, alluvium, shallow-marine sediments	Not available
Mainly on west coast in Perak and Selangor	Retreatment of tin tailings and tin slags	na	na	Strüverite	na	na	Not available
Mongolia							
50 km northeast of Hovd	Halzan Buregtei deposit	–	Peralkaline granite/syenite/metasomatite	Pyrochlore, columbite–tantalite	REE, zircon, yttrium oxides	Alkali microcline–albite granite	Resources: 35 000 t Ta ₂ O ₅ , 0.6 Mt Nb ₂ O ₅ , 1.0 Mt REE, 4.0 Mt ZrO ₂ , 0.1 Mt Y ₂ O ₃

Table 23. (continued)

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Russian Federation							
Altai Republic, southeast Altai near Kazakhstan border	Alakhinskoye deposit	–	Rare-metal (Li–F) granite	Columbite–tantalite (secondary ore)	Spodumene, mica, feldspar	Granite	Reserves: 68 Mt at 5% Li ₂ O ₅ , 15 000–20 000 t at 0.013 – 0.017% Ta ₂ O ₅
Chita Province, 270 km east-southeast of Chita	Etykinskoye mine	Etaginsky GOK	Rare-metal (Li–F) granite	Columbite–tantalite	Cassiterite, lithium mineralization	Granite	Proven reserves: 12 700 t at 0.013% Ta ₂ O ₅
Transbaykalia region, southern Chita Province	Orlovskoye mine	Orlovsky GOK	Rare-metal (Li–F) granite	Columbite–tantalite	Unknown	Granite	Reserves (pre-production): 30 000 t at 0.013 – 0.015% Ta ₂ O ₅
Chara region, northern Chita Province	Katuginskoye deposit	–	Peralkaline granite/syenite/metasomatite	Columbite–tantalite	REE, cryolite; Zr and Y enrichment	Granite	Reserves: 774 Mt at 0.025% Ta ₂ O ₅
Irkutsk region, eastern Sayan Mountains	Vishnyakovskoye mine	–	Granitic rare-metal pegmatite	Columbite–?tantallite	Beryl, lithium mineralization, Cs enrichment	Pegmatite	Not available
Locality not given	Beloziminskoye mine	State ownership	Mineralized deeply weathered regolith over ?carbonatite	Niobium and tantalum mineralization	Apatite	Unknown	Phosphate reserves: 20 Mt at 11.4% P ₂ O ₅
Locality not given	Zashikhinskoye deposit	State ownership	Unknown	Niobium and tantalum mineralization	Lithium mineralization	Unknown	Not available
Murmansk region, Lovozero district, Kola Peninsula	Umbozero mine	Lovozero Mining	Agpaitic nepheline syenite	Loparite (source of Nb, Ta, Ti, and REE)	Eudialyte, microcline, apatite, sphene	Nepheline syenite	Average Ta ₂ O ₅ grade: 0.015%
Primorskiy, 120 km north of Vladivostok	Voznesenovskoye mine	Yaroslavskiy GOK	Rare-metal (Li–F) granite	Columbite–?tantallite	Fluorite, beryl, lithium mineralization, Rb and Cs enrichment	?Granite	Resources: 17.2 Mt at 0.012% Ta ₂ O ₅ , 0.016% Nb ₂ O ₅
Tuva Republic, locality not given	Ulug-Tanzekskoye deposit	–	Unknown	Columbite–?tantallite	–	Unknown	Resources: >5000 t at 0.01% Ta ₂ O ₅

Table 23. (continued)

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Saudi Arabia 85 km southwest of Tabuk	Ghurayyah deposit	Tertiary Minerals	Peralkaline granite/syenite/metasomatite	Columbite–tantalite	Zircon; REE, U, and Th mineralization	Alkali granite plug	Resources: 385 Mt at 0.025% Ta ₂ O ₅ , 0.284% Nb ₂ O ₅ , 0.892% ZrO ₂
Thailand West coast peninsular Thailand (Phuket area) extending north into Burma	Numerous onshore and offshore dredging and gravel-pump mining operations	na	Placer, mineralized deeply weathered kaolinitic regolith mainly from rare-metal (Li–F) granites	Columbite–tantalite	Cassiterite, tungsten mineralization	Granite, pegmatite, kaolin, alluvium, shallow-marine sediments	Not available
	Retreatment of tin tailings and some tantalite ore	S. A. Minerals	na	Columbite–tantalite, strüverite	Cassiterite, tungsten mineralization	na	Not available
	Reprocessing of tin slags	Thiasarco	na	na	na	na	Not available
130 km south-southwest of Chiang Mai	Omkoi prospect	Unknown	Mineralized deeply weathered kaolinitic regolith over rare-metal (Li–F) granite	Columbite–?tantalite	Cassiterite, scheelite	Granite, pegmatite, kaolin	Not available

SOURCES: China — Yin et al. (1995); Yueqing et al. (1985)
 India — Singh and Sharma (1997)
 Malaysia — Schwartz et al. (1995)
 Mongolia — Mineral Resources Authority of Mongolia (2003a)
 Russian Federation — Chapleau Resources (2002a), Bisnis (2002a); Ames Laboratory (2002)
 Thailand and Burma — west coast: Schwartz et al. (1995); Chiang Mai region: Metal Mining Agency of Japan (2002)
 Saudi Arabia — Tertiary Minerals plc (2003)

NOTE: na not applicable

Malaysia, Thailand, and Burma

The tin industry has long been established in numerous places along the 1600 km of coastal lowlands of western Malaysia from Melaka to Georgetown, and from Phuket in Thailand northwards almost to Rangoon in Burma. In these areas, tin containing small amounts of tantalum is recovered from alluvial and eluvial terrestrial deposits, and also from offshore marine placer deposits. In 2002, it was estimated that about 24 tin mines were operating in

Malaysia alone (Minerals and Geoscience Department Malaysia, 2003). Principal mining methods are by gravel pump and dredging that represents about 90% of total output.

In these areas, tin–tantalum placer deposits are derived largely from the weathering of Mesozoic biotite granites that form part of the Main Range Granitoid Province in western peninsular Malaysia and southern peninsular Thailand. Smaller quantities are derived from rare-metal pegmatites.



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Figure 48. Tantalum mining provinces, mining operations, deposits, and prospects in Asia

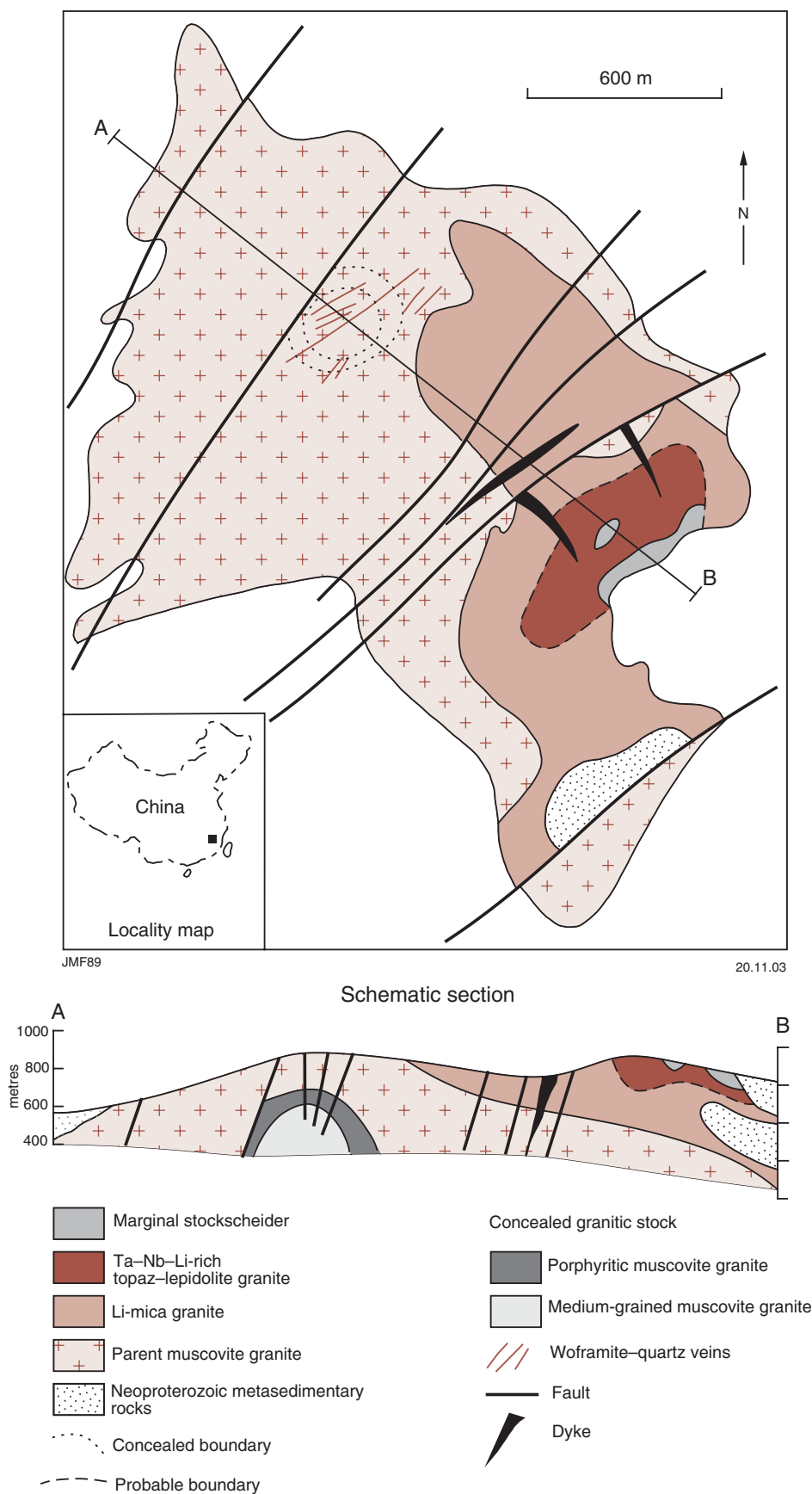


Figure 49. Geological map and schematic cross section of the Yanshan batholith. Diagram shows the relationship of the rare-metal granites overlying the parent muscovite granite. The Yichun Ta-Nb-Li deposit is located within the topaz-lepidolite granite (modified from Yin et al., 1995)

In both Malaysia and Thailand, tantalum is recovered by many small companies. The ore, mainly in the form of strüverite, is usually recovered as a byproduct of tin during secondary processing operations. Retreating of tin tailings to extract tantalum minerals is carried out in Thailand by S.A. Minerals, and in Malaysia by BEH Minerals. In 2000, these companies each recovered about 22 t of strüverite containing approximately 9–12% Ta₂O₅ (Linden, 2000).

In these countries, tantalum is also recovered from low-grade tin slags. In 2000, the Malaysian Smelting Corporation produced less than 22 t of Ta₂O₅ from this source, and in the same year the Thaisarco tin smelter in Thailand produced tin slags containing about 10% Ta₂O₅ and yielding about 45 t of tantalum pentoxide. Long-term production in this region appears to be falling due to the gradual decline in offshore tin-dredging operations.

Mongolia

Tantalum mineralization has been reported from many areas in Mongolia; however, deposits are mostly undeveloped and information is very limited. A summary of Mongolian rare-metal mineralization has been given in Kovalenko and Yarmolyuk (1995).

In central and eastern Mongolia, deposits such as Yugodzyr are incorporated in early Mesozoic rare-metal (Li–F) muscovite granites, and appear to be related to the mineralization style of the Yichun apogranite in China. However, reported grades are low at around 0.004 – 0.005% Ta₂O₅ (Kovalenko and Yarmolyuk, 1995). In the same geological environment, granitic rare-metal lithium- and/or muscovite-rich pegmatites are present and are represented by the Khukdel-Ula and Berkhin deposits. Related tantalite alluvial placer deposits are also present in some areas.

In central Mongolia, there are unusual rare-metal host rocks known as ‘ongonites’. These are topaz-bearing rhyolitic rocks enriched in lithium and fluorine, and are found as either volcanic or plutonic varieties. Plutonic ongonites often take the form of small dyke-shaped bodies up to 150–200 m long and only a few metres wide. Grades for Ta₂O₅ appear to be generally less than 0.01%, but may range up to 0.016%. Tantalum-rich ongonite deposits are present at Teg-Ula (volcanic style) and Ongon-Khairkhan (plutonic style).

The late Palaeozoic Halzan Buregtei deposit is located in northwestern Mongolia, 50 km northeast of the town of Hovd. This deposit is a peralkaline granite–metasomatite type forming part of the alkaline granites of the Halzan Buregtei Massif. Pyrochlore and columbite mineralization is concentrated in small, stock-like bodies of alkaline microcline–albite granite. Tantalum–niobium resources have been estimated at 35 000 t Ta₂O₅ and 0.6 Mt Nb₂O₅. Other significant mineralization includes zirconium oxide (4.0 Mt), rare earth oxides (1.0 Mt), and yttrium oxide (0.1 Mt). The deposit is reported to be in the exploration phase (Mineral Resources Authority of Mongolia, 2003b).

Russian Federation

Information relating to the location, geology, tantalum resources, and mining activities in the Russian Federation is extremely limited. However, it is known that there are about 20 tantalum deposits scattered across the Russian Federation. Most appear to be large, low-grade deposits that are currently uneconomic to mine because of their low-grade ore reserves, remote location, processing difficulties, lack of development capital, or a combination of these factors. Last recorded tantalum production was in 1998 from the Lovozyorskoye deposit in the Murmansk region.

Current estimates rate tantalum resources in the Russian Federation as very large; however, the average grade for Russian tantalum deposits is only 0.015% Ta₂O₅. It is believed that a large proportion of available tantalum resources is mostly contained in three large deposits: Katuginskoye in the Chita Province (774 Mt at 0.025% Ta₂O₅), Lovozyorskoye in the Murmansk region (resources not available), and Ulug-Tanzekskoye in the Tuva Republic (resources not available). Katuginskoye and Lovozyorskoye, plus the Beloziminskoye and Vishnyakovskoye deposits in the Irkutsk region (resources not available), have been identified as being generally the most economic deposits to mine and process in times of improved economic circumstances.

The most promising of the newly discovered deposits are Alakhinskoye in the Altai Republic with 15 000–20 000 t at 0.013 – 0.017% Ta₂O₅ (Chapleau Resources, 2002b), Voznesenovskoye and Progranichnoye in the Primorskiy region near Vladivostok with 17.2 Mt estimated at 0.012% Ta₂O₅ and 0.016% Nb₂O₅ (Bisnis, 2002b), and Zashikhinskoye in the Irkutsk region (resources not available).

Data relating to the tantalum deposits in the Russian Federation are shown in Table 23.

Saudi Arabia

The Ghurayyah tantalite deposit located in northwestern Saudi Arabia, about 85 km southwest of Tabuk, is currently being re-evaluated by Tertiary Minerals. The company has recently identified a tantalum resource of 385 Mt at 0.025% Ta₂O₅ to a depth of 250 m (Australia’s Paydirt, 2002b).

Ghurayyah is a peralkaline granite–syenite–metasomatite deposit hosted within a 900 m-diameter plug of alkali granite. The plug protrudes approximately 60 m above ground level. This section of the deposit contains about 10 Mt of the estimated resource, thus making for comparatively easy initial mining. Other identified resources included in the 385 Mt of ore are 0.284% Nb₂O₅ and 0.892% ZrO₂ (Tertiary Minerals plc, 2003).

South America

Four countries in South America have recorded tantalum deposits. Apart from Brazil, the world’s second-largest

tantalum producer, Bolivia and Guyana produce limited quantities of tantalum mined by small companies, local cooperatives, and artisanal miners from small workings and alluvial deposits. In recent years, tantalum exploration programs have been conducted in these two countries.

In French Guiana, small quantities of alluvial tantalite ore have been mined from about 12 sites (Gurmendi, 1997). Between 1969 and 1991 about 80–90 t of columbite–tantalite ore was produced. No other information about these operations is available.

A summary of the principal tantalum mines, deposits, and prospects in South America is given in Table 24 and their locations are shown on Figure 50.

Bolivia

The Santa Cruz Province in eastern Bolivia extends over large areas of the Precambrian Bolivian Craton that contains extensive granite–greenstone areas. In 2001, the General Minerals Corporation – Ranger Minerals joint venture explored three tantalum prospects about 160 km east of the city of Santa Cruz. The prospects of Agua Dulce, Rio Blanco, and Los Patos are zoned rare-metal pegmatites with associated colluvial and alluvial placers containing anomalous levels of tantalum and niobium. In its program of exploration, the joint venture carried out costeaning of weathered pegmatite and adjacent colluvial material. Geochemical values for Ta₂O₅ ranged from 0.003 to 0.020%. In October 2001, the joint venture was conducting bulk-washing trials from colluvial material to evaluate tantalite concentrate potential. Possible commercial quantities of muscovite mica occur at Agua Dulce and Los Patos, as well as alkali feldspar at Agua Dulce (General Minerals Corporation, 2002).

Brazil

Brazil is the world's second-largest tantalum producer after Australia, with production in 2001 estimated at 300 t, and an estimated reserve base of 53 000 t (Cunningham, 2002). Tantalum mineralization has been reported from Amazonas, Minas Gerais, Rondônia, and Bahia states, and most deposits appear to be related to or derived from Archaean–Palaeoproterozoic albitic granites or rare-metal pegmatites.

Artisanal mining

Artisanal mining is common in many areas of Brazil. This is carried out as small alluvial mining operations, mainly by local prospectors known as 'garimperos'. Apart from much artisanal mining in the Pitinga area in Amazonas State, the garimperos are active in tin–tantalum areas in Minas Gerais and Bahia states. Another area of interest is in the tin mining district of Bom Futuro, about 210 km east-southeast of Porto Velho in Rodônia State in the far west of Brazil. Here, there are many alluvial operations extracting tin and tantalite derived from Archaean–Palaeoproterozoic peraluminous, greisenized, albitic

granite. Linden (2000) estimated that the Brazilian garimperos mine and sell about 45 tpa of tantalite each year.

Amazonas

The country's largest mine is at Pitinga, located in northern Brazil in Amazonas State, about 260 km north of Manaus. In this area of the Archaean–Palaeoproterozoic Amazon Craton, there are extensive areas of cassiterite and columbite–tantalite mineralization associated with granites or eluvial and alluvial placer deposits. The Pitinga mine, owned by Paranapanema SA, is a 12 000 tpa tin mine producing tantalum and niobium concentrates as by-products. Current operations are largely dredge mining of cassiterite and columbite–tantalite alluvial placer deposits to a depth of 8 m. It appears that available resources in these deposits are becoming limited and a change will eventually have to be made to mining tin–tantalum–niobium resources from existing deposits in peralkaline albitic granites. It is known that the company has plans to develop the hard-rock mine to ultimately produce about 450 tpa Ta₂O₅.

At the mine site, tin and columbite–tantalite primary concentrates are produced. The columbite–tantalite concentrate is transported to the Sao Tiago oxide plant near Sao Paulo in eastern Brazil, where approximately 100 tpa of refined Ta₂O₅ is produced. The company's nearby Mamore tin smelter has large stockpiles of tin–tantalum–niobium slags that are estimated to contain almost 2270 t of Ta₂O₅; however, extraction of refined Ta₂O₅ from this resource is likely to prove difficult (Linden, 2000).

Paranapanema SA has a subsidiary company Taboca that operates a tantalum mine further south in Amazonas, near Manaus; however, no details of this operation are available.

Minas Gerais

The Nazareno mine is located 40 km west-southwest of Sao Joao del Rei in Minas Gerais State. The tantalite deposit is likely to be related to granitic rare-metal pegmatites emanating from a peraluminous granite forming part of the Archaean–Palaeoproterozoic Sao Francisco Craton of eastern Brazil. The mine, operated by Cia. Industrial Fluminense (a wholly owned subsidiary of Metallurg Inc.), is designed to produce up to 45 tpa Ta₂O₅. The company operates a tantalum and niobium extraction plant near Sao Joao del Rei in conjunction with a small tin smelter that also produces a tantalum-rich slag. The company also buys tin and tantalite from other local producers for processing with the Nazareno concentrates. Together with Ta₂O₅ refined from slag, total refined Ta₂O₅ production is about 127 tpa (Linden, 2000).

Guyana

Current tantalum prospecting in Guyana is concentrated in the Morabisi area, about 190 km west-southwest of Georgetown. At this locality, an oval-shaped

Table 24. Significant tantalum mineralization in South America

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Bolivia							
Santa Cruz Province, Precambrian shield area, eastern Bolivia	Small deposits and workings	Small mining companies and cooperatives	Placer, granitic rare-metal pegmatites	Columbite–tantalite	–	Stream sediments, pegmatite	Not available
160 km east of Santa Cruz	Agua Dulce prospect Rio Blanco prospect Los Patos prospect	General Minerals Corporation/ Ranger Minerals	Placer, granitic rare-metal pegmatites	Columbite–tantalite	Muscovite, K-feldspar, kaolin, rutile, ilmenite	Stream sediments, pegmatite	Ta ₂ O ₅ grade: (Agua Dulce) 0.003 – 0.020% (geochemical samples)
Brazil							
Amazonas, Minas Gerais, Rondônia, Bahia states	Numerous small alluvial deposits	Small mining operations and artisanal miners	Placer	Columbite–tantalite	Cassiterite	Stream sediments	Not available
Amazonas State, 260 km north of Manaus	Pitinga dredging operation	Paranapanema SA	Placer, peralkaline granite/syenite/metasomatite	Columbite–tantalite	Cassiterite, zircon, REE, cryolite	Stream sediments, granite	Substantial resources
Minas Gerais State, 40 km west-southwest of Sao Joao del Rei	Nazareno mine	Cia. Industrial Fluminense (Metallurg Group)	Granitic rare-metal pegmatite	Columbite–tantalite, microlite	Cassiterite	Pegmatite	Not available
Guyana							
190 km west-southwest of Georgetown	Morabisi prospect	Artisinal mining	Placer, granitic rare-metal pegmatite	Columbite–tantalite	REE, base metals; Mn, U, and W mineralization	Stream sediments, pegmatite	Anomalous Ta geochemical values: 200–2700 ppm
190 km west-southwest of Georgetown	Morabisi mine	Tanimex	Placer	Columbite–tantalite, euxenite	Ilmenorutile, ilmenite, xenotime, rutile, beryl	Stream sediments	Resources: 1.53 Mm ³ of alluvial material containing about 0.89 – 1.48 kg/m ³ of Ta minerals
190 km west-southwest of Georgetown	Kunaballi mine						

SOURCES: Brazil — Metallurg (2002); Paranapanema SA (2002); National Department of Mineral Production Brazil (2002)
 Guyana — Guyana Geology and Mines Commission (2002)
 South America (general) — U.S. Geological Survey (2002)



Figure 50. Tantalum mining operations, deposits, and prospects in South America

Mesoproterozoic granitic mass is present. The granite body is about 10 km wide and is ringed by dolerite dykes and gabbroic sills. The granite hosts a number of rare-metal pegmatites containing concentrations of columbite–tantalite and associated rare earth elements, manganese, tungsten, and uranium. Structural concordance of the pegmatites with margins of the surrounding mafic intrusions indicates that the pegmatites may have been formed by the intrusion of a subsurface mafic body causing partial melting of the granite. A geochemical survey carried out in the area detected stream-sediment values for tantalum in the range 200–2700 ppm (Guyana Geology and Mines Commission, 2002).

Alluvial and eluvial tantalite-rich placer deposits have been identified in surrounding areas. Investigations by Tanimex Inc. in the Morabisi and nearby Kunaballi areas have identified approximately 1.53 Mm³ of workable alluvial placer deposits extending over large areas, and estimated to contain about 0.9–1.5 kg/m³ of tantalum minerals (Geolisting.com, 2003).

Europe

Currently there is no tantalum production in Europe. Portugal and France are countries with a previous history

of tantalum mining. In recent years, tantalum exploration programs have been carried out in Finland, Ireland, and Spain.

A summary of the principal tantalum mines, deposits, and prospects in Europe is given in Table 25 and their locations are shown on Figure 51.

Finland

In August 2000, Tertiary Minerals began an exploration program for tantalum at Rosendal, located on Kemio Island in southwest Finland. The Rosendal deposit is a rare-metal pegmatite dyke that had been previously discovered and evaluated by the Geological Survey of Finland. At that time, resources were estimated at 1.3 Mt at 0.029% Ta₂O₅ and 70% Na-feldspar to 100 m depth (Minesite.com, 2002).

Tertiary Minerals completed a 14-hole drilling program in May 2002 to evaluate the geometry of the pegmatite dyke and to carry out a revised resource estimate. Drillhole results ranged from 0.024% Ta₂O₅ over 20.2 m to 0.128% Ta₂O₅ over 3.0 m, and the weighted average Ta₂O₅ grade from the drilling program was 0.035%. The exploration program also showed the dyke to be at least 500 m in length and open at depth (Mining Journal, 2002c).

Tertiary Minerals is looking at the possibility of developing a multi-purpose mine by also processing Na-feldspar that could be recovered from the gravity tailings once the rare-metals have been removed. The company's study has revealed that from a 150 000 tpa openpit mining operation it may be possible to produce almost 30 tpa Ta₂O₅ concentrates and about 84 000 tpa premium-grade sodium feldspar (Industrial Minerals, 2002b).

France

The Beauvoir–Echassières mine in the Massif Central region of central France is located in a small leucogranite stock within the late Palaeozoic Echassières massif. Mineralization is contained within the late-phase rare-metal Beauvoir Granite that takes the form of a mineralized cupola overlying the host granite and is of a style similar to the Yichun apogranite deposit in China. The deposit contains estimated resources of 20 000 t at an average 0.012% Ta₂O₅, as well as significant grades of tin, lithium, and niobium. The deposit is also deeply weathered in places, which has permitted the mining of high-grade kaolin for use as china clay (Raimbault et al. 1995).

Currently, rare-metal mining from the deposit is inoperative, partly due to metallurgical problems associated with lithium recovery and also due to environmental concerns.

Ireland

In the Blackstairs Mountains near Carlow in the southeast of the Republic of Ireland, late Ordovician granites intrude

Table 25. Significant tantalum mineralization in Europe

Country/province/site	Mine/deposit/prospect	Exploration/mining company	Deposit style	Tantalum minerals	Other minerals	Host rock	Reserves/resources/grades
Finland Kemio Island, 50 km south-southeast of Turku	Rosendal deposit	Tertiary Minerals	Granitic rare-metal pegmatite	?Columbite–tantalite	Na-feldspar, quartz, mica	Pegmatite	Resources (1989): 1.3 Mt at 0.029% Ta ₂ O ₅ . Drilling (2002): 0.024% Ta ₂ O ₅ over 20.2 m to 0.128% Ta ₂ O ₅ over 3 m
France Allier, Massif Central region	Beauvoir–Echassières mine	Société des Kaolins de Beauvoir	Mineralized, deeply weathered regolith over rare-metal (Li–F) granite	Columbite–tantalite, microlite	Lepidolite, topaz, albite, cassiterite, fluorite, kaolin, zinnwaldite, phosphate mineralization	Kaolinized granite	Resources: 20 000 t at 0.012% Ta ₂ O ₅ (average grade) (maximum grade = 0.03%)
Ireland Carlow, about 25 km south- southeast of Carlow	Blackstairs Mountains prospect	Angus & Ross	Rare-metal (Li–F) granite	Columbite–?tantalite	Lithium and tin mineralization	Granite, pegmatite	Peak Ta values: 0.001 – 0.002% (soil samples)
Portugal Guarda, 18 km south-southwest of Pinhel	Gonçalo prospect	–	Granitic rare-metal pegmatite	Columbite–tantalite (secondary ore)	Lepidolite, cassiterite, beryl	Pegmatite	Not available
Viana do Castelo, 10 km northeast of Caminha	Serra de Arga area prospects		Rare-metal (Li–F) granite	Columbite–?tantalite	Cassiterite	Granite	Not available
Spain Pontevedra, Forcarey area, 50 km northeast of Vigo	Forcarey Sur prospect	Golden Dynasty Resources	Granitic rare-metal pegmatite, rare- metal (Li–F) granite	Columbite–tantalite, strüverite	Cassiterite, spodumene, beryl, albite, phosphate mineralization	Pegmatite, kaolinized and greisenized granite	Inferred resources: 7.35 Mt Indicated average grade: 0.016% Ta ₂ O ₅ , 0.109% Sn

SOURCES: Finland — Minesite.com (2002)
France — Raimbault et al. (1995)
Ireland — Angus & Ross plc (2000)
Portugal and Spain — U.S. Geological Survey (2002)



Figure 51. Tantalum mining operations, deposits, and prospects in Europe

a sequence of early Palaeozoic metamorphosed sedimentary and volcanic rocks. In the area of the granite–sedimentary rock interface is a major deformation zone trending northeast. Pegmatite and microgranite intrusions are distributed along 35 km of this zone.

In 2001, Angus & Ross carried out soil and stream-sediment sample geochemical surveys in the area. Exploration was based on anomalous values for tantalum from a previous stream-sediment survey conducted by the Geological Survey of Ireland. Results from the earlier survey indicated that anomalous tantalum values were only partially coincident with the zone of pegmatite intrusion.

In the soil geochemical survey subsequently carried out by Angus & Ross, 1895 samples were collected over an area of about 15 km². Peak values for the soil geochemical survey were 10–20 ppm Ta (Angus & Ross plc, 2000). Distribution of tantalum anomalies from this survey indicated that the tantalum mineralization may be related to a rare-metal (Li–F) apogranite. Follow-up trenching and drilling surveys are planned.

Portugal

In Portugal, minor tantalum mineralization is associated with a long-established tin-mining industry at Serra de

Argã in the northwest of the country, where tin has been mined from post-tectonic rare-metal granites. Tantalum is also associated with lithium contained in aplitic pegmatites embedded in late Palaeozoic granites in the Gonçalo area in eastern Portugal.

Spain

The Forcarey Sur tantalum prospect is located about 50 km northeast of Vigo in northwest Spain. In this area, late Palaeozoic micaceous, peraluminous granites were intruded into Silurian to Devonian sedimentary rocks, resulting in localized metamorphism to greenschist–amphibolite facies. Late-phase, zoned rare-metal pegmatites were subsequently intruded into the resulting schistose metasedimentary rocks. Albite-rich zones within the pegmatites have been enriched in beryllium, lithium, tantalum, niobium, tin, and phosphorus.

In 1999, Golden Dynasty Resources identified two pegmatite zones along a strike length of 2 km and with average widths of 10 m (Newman, 1999). Previous investigations indicated that these areas may contain inferred resources of 7.35 Mt at indicated average grades of 0.016% Ta₂O₅ and 0.109% Sn. A spodumene resource was also identified within these zones, but no analytical values for lithium were reported.

Fetherston

Additional reconnaissance in the area identified numerous zones of tantalum mineralization present in other pegmatites and greisenized, kaolinized granites.