

# Mineral Commodity Report 11 — Tin

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## Discovery and Origin of Names

The name tin comes from the Anglo-Saxon *tin* for the metal, the symbol Sn is from *stannum*, the Latin for tin, and the ore mineral cassiterite is named after the Greek name for tin, *kassiteros*.

The earliest use of tin was in the copper-based alloy bronze, about 5000 years ago in Egypt and Mesopotamia, and pure tin ingots were first produced between 3500 and 3100 years ago. The ancient coppersmiths discovered that bronze was easier to cast and more workable than copper because of its lower melting point (Cu at 1080°C vs. bronze with 20% Sn at 890°C). Bronze produced superior weapons and tools, hard enough to retain a cutting edge. However, the production of bronze was severely restricted until after about 4000 years ago because, although copper was readily available in the Middle East, the supply of tin was limited. As tin supplies from Asia Minor (particularly Caucasia) and Persia were exhausted, Phoenician and Greek traders travelled as far as Cornwall in England, Brittany in France, Cantabria in Spain, and central Germany to obtain tin for the Middle East. Tin greatly influenced patterns of early trade routes and became a standard metal of commerce during the European Bronze Age.

Tin was mined in Spain from the beginning of the Bronze Age, while the working of mines in France and England began about 2500 years ago. Ore was obtained initially from alluvial deposits and later during Roman times from underground mines exploiting lode deposits.

The East Indies and Malay states became producers of alluvial tin in the eighth century.

The ancient Egyptians considered tin and lead different forms of the same metal. Aristotle knew of the existence of grey tin. In the first century AD, the Roman historian Pliny mentioned the use of lead-tin alloys (solders) for joining metals. Articles of copper coated with tin were also produced by the Romans. However, tinplate, which is tin-coated iron or steel, did not come into wide use until the 1500s, in Europe.

## Major Ores and Minerals

The principal ore of tin is the mineral cassiterite (or tinstone),  $SnO_2$ , although stannite  $Cu_2FeSnS_4$  and teallite  $PbSnS_2$  are also present in some deposits. Many Bolivian deposits contain tin-bearing sulphosalt and sulphide minerals which are difficult to beneficiate and less than 50% of the tin is recovered.

Tungsten is a common associate in tin ores; molybdenum and silver are present in some deposits, but gold is generally absent.

|                           |                                 |
|---------------------------|---------------------------------|
| Symbol                    | Sn                              |
| Atomic no.                | 50                              |
| Atomic wt                 | 118.69                          |
| Specific gravity          | 5.77, 7.29                      |
| Valence                   | 4, 2                            |
| Melting point             | 231.9°C                         |
| Boiling point             | 2270°C                          |
| Crustal abundance         | 2.5 ppm                         |
| Preferred analysis method | X-ray fluorescence spectroscopy |
| Routine detection limit   | 4 ppm                           |

## Properties

Tin is a metallic element in group IVA (or 14) of the periodic table. It has two allotropic forms, white ( $\beta$ ) or ordinary tin, and grey ( $\alpha$ ) tin, the low temperature ( $<13.2^\circ\text{C}$ ) form. Ordinary tin is a silvery-white, soft, malleable, somewhat ductile, and moderately heavy metal with a highly crystalline structure. It is nontoxic, easily melted (232°C), has a low coefficient of friction, extreme fluidity in the molten state and excellent wetting characteristics. Ordinary tin takes a high polish and is used to coat other metals to prevent corrosion or chemical action. A thin film of stannic oxide forms on tin when exposed to air and provides an invisible, protective coating preventing further corrosion. Tin is attacked by strong acids, alkalis and acid salts, but near neutral pH solutions do not affect it appreciably. Grey tin is an amorphous, greyish powder with a lower density than white tin (specific gravities of 5.77 and 7.29 respectively), and is formed by cooling of high purity white tin at temperatures below 13.2°C. When ordinary bar tin is bent it issues a crackling sound called tin cry, caused by the frictional breaking of the tin crystals.

Cassiterite is reddish brown to black in colour (more rarely yellow or white), with an adamantine to submetallic lustre, a hardness of 6 to 7 and a specific gravity of about 7. It has tetragonal crystal symmetry, forming crystals as prisms and pyramids, frequently as twins, but more commonly it is massive. Cassiterite with a reniform shape and a radiating fibrous appearance is called wood tin.

## Formation

Tin is preferentially concentrated by magmatic differentiation processes and is generally found as lode deposits and disseminations associated with peraluminous leucocratic granitic rocks or their extrusive equivalents, or as placer deposits derived from their erosion. Placer deposits are the source of about 70% of total world tin production. The following classification scheme of tin deposit types is drawn from reviews by Taylor (1979), Hutchison (1983), Hosking (1988), Menzie et al. (1988) and Reed (1989).

## **Greisen deposits**

Greisen deposits are formed by post-magmatic metasomatic fluids in or near the apical portions of late-stage leucogranites, and range from incipient greisens (muscovite  $\pm$  chlorite, tourmaline and fluorite) to massive greisens (quartz + muscovite + topaz  $\pm$  fluorite and tourmaline). The mineralisation occurs as large, irregular or sheet-like bodies, extending downwards for 10–100 m below the roof of the granite. Ore and associated minerals include cassiterite, wolframite, bismuthinite, molybdenite, arsenopyrite, base-metal sulphides, beryl, tantalum-columbite and rare earth elements (REE). Most economically viable greisen deposits contain 5–50 million tonnes of ore at grades ranging between 0.1 to 0.4% Sn, with coproduct tungsten, molybdenum and/or lithium.

Greisen deposits include the Erzgebirge (Ore Mountains) on either side of the Czech-German border (e.g. Cinovec, Czech Republic; and Sadisdorf, Germany); East Kemptville, Nova Scotia, Canada; Talushan and Chiu Lung Nao in southeast China; the Blue Tier Tinfield in Tasmania; and the Zaaiplaats and Rooiberg tin fields of the Bushveld Complex of South Africa.

## **Hydrothermal lodes**

Lode deposits are characterised by the classic, zoned fissure vein or replacement lode deposits of Cornwall. The lodes occur in the roof, wall and contact metamorphic aureole zones of leucogranite intrusions. They are commonly associated with greisens in the roof zone, but also occur within sedimentary country rocks at some distance from the granite intrusions. The mineralogy is varied: cassiterite may be accompanied by wolframite, arsenopyrite, molybdenite, scheelite, beryl, base-metal sulphides, stannite, and/or bismuthinite. Other important fields include Herberton in North Queensland; Aberfoyle in Tasmania; Sungai Lembing in Pahang, Malaysia; and Billiton in Indonesia. The deposits are generally small (<4.5 t of ore), but high grade (0.7–2.3% Sn).

## **Porphyry deposits**

These are typified by the rich tin-silver veins of southern Bolivia, present in ten tin centres including Llallagua-Uncia, Huanuni and Potosi. The deposits are associated with Tertiary felsic volcanic and/or high level porphyritic intrusive centres, with well defined zones of propylitic, sericitic, argillic and silicic alteration. Veins, pipes and hydrothermal breccias contain cassiterite, and Ag, Sn, As, Bi, Pb and Zn sulphosalt and sulphide minerals, with some deposits exhibiting mineral zoning. Some tin occurs in tin-bearing sulphide and sulphosalt minerals such as teallite, franckeite and cylindrite, from which recovery of the tin is metallurgically difficult. Catavi at Llallagua, the world's largest tin mine working primary ore, has produced more than 500,000 t of tin. The silver porphyry of Cerro Rico de Potosi is estimated to contain 828 Mt grading 150–250 ppm Ag and 0.3–0.4% Sn, but such low grade deposits are not now economic producers. Bolivian ores now average about 0.7% Sn, as compared to earlier operations when mill-head grades of more than 5% were common.

A deeper level example is Ardlethan in New South Wales, Australia, where cassiterite, wolframite and sulphides are disseminated in breccia pipes associated with fractionated granite of Siluro-Devonian age (Ren et al., 1995).

## **Skarn deposits**

Skarn deposits occur around the upper parts of granitoid bodies intruding carbonate rocks. Most skarn deposits occur within 300 m of leucogranite intrusions and may be localised by fractures and dikes. They are characterised by a gangue mineral assemblage including calcium and magnesium silicate minerals. Tin minerals are erratically distributed and include cassiterite and malayaite  $CaO.SnO_2.SiO_2$ , and various other tin-bearing silicate minerals with nonrecoverable tin. Other common minerals include magnetite, pyroxene, garnet, tourmaline, fluorite and various sulphide minerals. Examples are Pinyok, Thailand; Kuala Lumpur field, Malaysia; Beatrice Pipe, Perak, Malaysia; and Moina, Tasmania (30 Mt of 0.15% Sn).

## **Cassiterite-sulphide replacement deposits**

These deposits are replacements of dolomitic or calcareous sediments, although calcium silicate skarn minerals are generally uncommon. Most are associated with dikes and small plutons of hydrothermally altered granite, to which a genetic connection is inferred. They include large stratabound/stratiform deposits and pipes, and small irregularly shaped deposits. Common ore minerals are pyrrhotite, arsenopyrite, cassiterite, chalcopyrite, ilmenite and fluorite. Examples of stratabound/stratiform deposits are Renison Bell (one of the world's largest operating underground tin mines, producing 5000–6000 t Sn per year), Cleveland and Mt Bischoff in Tasmania, and Dachang and Gejiu ore fields in China. Replacement pipes are found in the Kinta Valley, Malaysia (excluding the skarn-type Beatrice Pipe). Like the skarn deposits, replacement deposits consist chiefly of cassiterite and sulphide minerals. They represent the largest hard rock deposits, with 1–30 Mt of ore at grades ranging between 0.5 and 1.2% Sn.

## **Pegmatite/aplile deposits**

Most tin-bearing pegmatites and aplites are Precambrian quartz-microcline types, with albite and muscovite, and many also contain topaz, spodumene and tourmaline. Cassiterite is usually recovered as a coproduct along with columbite, tantalite, beryl, spodumene and wolframite. Examples include Bikita in Zimbabwe; Manono-Kitotolo in Nigeria; Greenbushes in Western Australia; and pegmatites at Phuket, Thailand. Worldwide tin production from pegmatites is minor, but they are an important tin source in the formation of some placers.

## **Rhyolite-hosted deposits (Mexican type)**

These deposits occur as veinlets of cassiterite in alkali-feldspar rhyolite. Cassiterite is accompanied by specular hematite, cristobalite and other silica minerals, fluorite, mimetite and adularia. Deposits of this type are generally Tertiary in age and occur in the Sierra Madre Occidental of Mexico, and also in Bolivia, Argentina and New Mexico's Black Range. Grades are generally erratic and quite low.

Most deposits contain between 230 and 3900 t of ore at grades between 0.14 and 1.04% Sn. Production of tin from these deposits has been limited to small placer operations that have produced a few tens of tonnes of tin each.

### **Massive sulphide deposits**

Fine-grained disseminated cassiterite also occurs in stratiform bodies of mixed sulphide minerals mined for Pb, Zn and Cu. Although, massive sulphide deposits are minor tin producers worldwide, for many years the largest tin-producing mines in North America were massive sulphide deposits at Sullivan (British Columbia) and Kidd Creek (Ontario), where tin was a coproduct.

### **Placer deposits**

Because cassiterite is both heavy and relatively stable in the surficial environment, it is readily concentrated in placers. Alluvial placers are the major source, although eluvial and colluvial placers formed from deep weathering of cassiterite-bearing greisens and vein swarms are common in the Southeast Asia tin province. In this province many alluvial placers, now lying offshore because of the postglacial rise in sea level, have been mined by seagoing dredges. Tin dredges can work placer deposits with grades less than 0.01% tin. Tin placers locally contain recoverable amounts of other heavy minerals such as columbite-tantalite, wolframite, ilmenite, monazite and xenotime.

### **Uses**

Formerly, the largest consumer was tin plate, widely used for tin-plated steel containers (tin cans) for preserving foods and beverages. This usage decreased from 40% of world use in 1978 to 27% in 1993 (Shaw, 1995), because of increasing substitution by aluminium and tin-free steel. Because pure tin is relatively weak, it is not put to structural uses unless alloyed with other metals. Numerous alloys of tin are used, including soft solder (Sn, Pb), bronze (Sn, Cu), type metal (Sn, Pb, Sb), pewter (e.g. Britannia Metal: Sn, Sb, Cu), bell metal, babbitt or bearing metal (Sn, Cu, Sb), and low-temperature casting alloys. Solder and other fusible alloys are now the main consumer of tin, with 33% of world usage in 1993. It is also used as an alloy with titanium in the aerospace industry, and with niobium as a superconductor electromagnet at temperatures below 18°K.

Compounds of tin are used in a wide variety of industrial applications. The Pilkington process for most window glass, floats molten glass on molten tin to produce the flat surface. Tin compounds are used as stabilisers in plastics, and tin salts sprayed onto glass provide conductive coatings for panel lighting. Stannous chloride  $SnCl_2$  is used in galvanising and as a reducing agent in the manufacture of polymers and dyes; stannous oxide  $SnO$  is used in making tin salts for chemical reagents, plating and glass manufacture; stannic oxide  $SnO_2$  is a useful catalyst in certain industrial processes and a polishing powder for steel; stannic chloride  $SnCl_4$  is widely used as a stabiliser in perfumes and soaps, and as a starting material for other tin salts and organo-tin compounds; and stannous fluoride  $SnF_2$  is a major component of toothpastes; stannic sulphide  $SnS_2$ , known also as mosaic gold, is used in powdered form for bronzing articles made of plaster of paris

or wood; and organo-tin chemicals are used as pesticides, fungicides and in the manufacture of polyvinyl chloride (PVC).

### **Price**

During the early 1980s, the International Tin Council kept the price of tin artificially high by maintaining a buffer stock. In mid 1985 the ITC ran out of funds and collapsed, leaving a large stock which caused the market price of tin to plummet. Subsequently, leading producing countries agreed on annual export quotas as a means of limiting supplies and reducing surplus stocks. World stocks were reduced from 92,000 t at the end of 1985 to about 20,000 t by March 1996. Correspondingly, prices increased to a mid year peak in 1995 of about US\$6,900/t, but had eased to US\$6,200/t at the beginning of March 1996.

### **World Production and Consumption**

During 1994 total mine production of tin was 109,000 t, whereas total refined supply was 170,000 t, slightly less than total refined demand of 176,000 t (Shaw, 1995). China produced about a quarter of the world supply in 1994 (50,000 – 55,000 t), whereas tin-in-concentrate production figures for other major supplying countries were: Indonesia, 30,600 t; Peru, 20,000 t; Brazil, 17,000 t; Bolivia, 16,100 t; Malaysia, 6,500 t (61,400 t in 1980); Australia, 6,400 t; Portugal, 4,300 t; and Thailand, 3,100 t (Shaw, 1995). The low tin prices of the last 10 years have caused the closure of many operations, although production has been maintained in Indonesia and expanded in Peru. A significant improvement in tin prices could encourage additional mine production, especially in Malaysia and Indonesia where alluvial miners can react swiftly to improved market conditions.

Substantial resources of tin are known mostly in Southeast Asia, Bolivia, Brazil and Peru.

### **Ore Processing, Smelting and Refining**

Material mined from placer deposits is concentrated to about 70–77% cassiterite by gravity methods, and because of relatively few impurities, it can be smelted without pretreatment. Ores from lode deposits are ground and washed, and in some cases pretreated before smelting. Roasting is used to oxidise impurities such as sulphur and arsenic, and acid leaching may also be employed, particularly if there are high concentrations of copper, lead, antimony and/or bismuth.

Smelting can be done in a reverberatory, rotary or electric furnace and involves the reduction of cassiterite by coal or carbon monoxide. Smelting is carried out in two stages because of the tendency for iron to be co-reduced with tin. The primary smelting process is controlled so that only a part of the tin is reduced, thus keeping the concentration of impurities to a minimum. In the second stage, the tin-rich slag is re-smelted and the impure tin metal that is produced is recycled to the first stage for further smelting. After smelting the tin is refined to 99.8% pure by heat treatment or

electrorefining. Heat treatment may be by liquidation in a reverberatory furnace or by boiling in large kettles.

Secondary tin from metal scrap makes up a significant part of the market, for example about 25% of the total tin consumed in the US. Most of this comes from tin-bearing alloys, reworked by secondary smelters into alloys and chemicals. Additional tin of high purity is recovered from the detinning of tinplate scrap.

## New Zealand Occurrence and Resources

The occurrence of tin in New Zealand has been reviewed by MacDonald (1965), Officers of the New Zealand Geological Survey (1970), Williams (1974), and Brathwaite and Pirajno (1993). Morgan (1927) and Railton and Watters (1990) listed occurrences of tin minerals, and Hutton (1950) listed occurrences of cassiterite found in heavy mineral concentrates. The main occurrences of tin in New Zealand are in greisen and alluvial deposits in southern Stewart Island, and in association with scheelite in hydrothermal vein and greisen deposits in Westland.

### Greisen deposits

Cassiterite is present in several hydrothermal vein and greisen type W-Sn occurrences along the western side of the Karamea Batholith in southwest Nelson and Westland (Pirajno, 1985; Tulloch and Mackenzie, 1986; Kutsukake, 1988; Brathwaite and Pirajno, 1993). The mineralisation is localised in the apical (cupola) zones of structurally controlled granitic sheets or stocks, and in their contact zones with Greenland Group greywacke or earlier granitoid rocks. In contrast to classic Sn-W granite provinces (eg northeast Tasmania), the mineralisation is unusual in containing scheelite with little wolframite, cassiterite, fluorite and topaz (Tulloch and Brathwaite, 1986). This mineralogy indicates a low fluorine activity in the magmatic hydrothermal fluids, and is correlated by Tulloch and Robertson (1987) with low fluorine (<1000 ppm) in the associated granites, compared to high fluorine (>3000 ppm) in classic Sn-W granites. Occurrences where cassiterite is the main mineral of economic interest are Britannia Stream, Falls Creek and Tin Range. Other occurrences where traces of cassiterite accompany scheelite are Bateman Creek, Kirwans Hill, Barrytown and Doctor Hill. These deposits are described in the Tungsten commodity report (page 19–27 this volume).

**Britannia Stream, Waimangaroa:** Kutsukake (1988) reported minute cassiterite crystals with disseminated pyrite, chalcopyrite and hematite in a greisenised apophysis of the Britannia Granite pluton.

**McConnochie Creek:** High level granite sheets and stocks of the Karamea Batholith intrude hornfelsed Greenland Group metasedimentary rocks near Reefton, on the western slopes of the Victoria Range. At McConnochie Creek, a small granite body has an incipient greisen mineralogy consisting of albite-quartz-muscovite with accessory quantities of tourmaline, topaz and illite (Pirajno, 1982). Both endogranite and exogranite quartz vein systems are present, mineralised with pyrite, chalcopyrite, marcasite, molybdenite and native

bismuth, and minor sphalerite, argentite and cassiterite. No scheelite was found at McConnochie Creek.

**Falls Creek:** Cassiterite and scheelite occur in quartz-tourmaline veins in a weakly greisenised biotite granite stock, similar to the mineralisation at nearby Doctor Hill (Mackenzie, 1983; Maxwell, 1989). Metasedimentary roof pendants are common as wedges subparallel to mineralised vein sets which extend at least 100 m below surface. Veins greater than 0.1 m wide have alteration zones greater than 0.2 m wide, comprising a greisen assemblage of quartz-tourmaline, with minor pyrite, arsenopyrite, scheelite, and cassiterite, and rarely pyrrhotite, molybdenite, topaz and fluorite. One 145 m diamond drill hole gave best intersections of 0.4 m of 0.3% Sn and 2%  $WO_3$ , and 0.3 m of 0.49% Sn and 0.96%  $WO_3$ . Maxwell (1989) considered that the mineralisation is exposed at a level below the apex of potentially productive greisen apophyses, although these apophyses may occur in an untested area to the southeast.

**Tin Range, Stewart Island:** On the Tin Range, in the south of Stewart Island, a greisen zone carrying wolframite and cassiterite is present in a roof pendant of biotite-muscovite-sillimanite schist and quartzite at the contact with biotite granite (Williams, 1934a). The greisen is a quartz-topaz-biotite-muscovite rock traversed by veinlets containing quartz, topaz, garnet, wolframite, sparse cassiterite and rare gahnite (zinc spinel). The width of the richest wolframite-cassiterite zone is about 0.3 m (McKay, 1890).

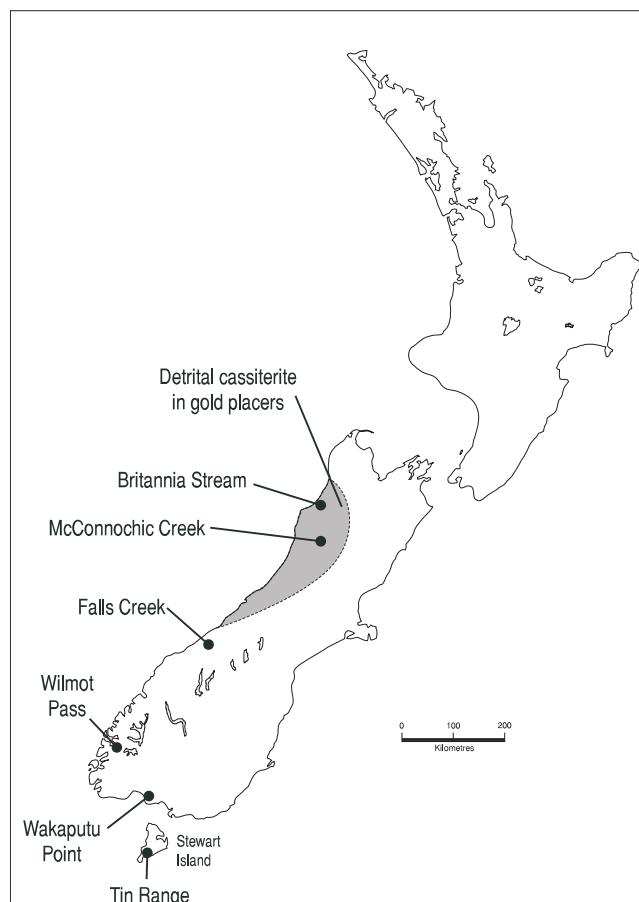


Figure 1: Location of tin occurrences.

**Geochemical Anomalies in west Nelson:** A reconnaissance geochemical survey for tin-tungsten-molybdenum in west Nelson by BP Oil NZ Ltd, defined a broad area of anomalous tin and tungsten from paired pan concentrate and stream sediment samples (Christie, 1984). The most anomalous sample (40 ppm Sn and 55 ppm W) came from an eastern tributary of the Ugly River. Other anomalous samples came from a northern tributary of the Spey River, the headwaters of the Ugly River, an eastern tributary of the Beautiful River, False Creek, and the upper section of Venus Creek.

### Pegmatite deposits

**Wilmot Pass, Fiordland:** Turner (1937, p 243) noted disseminated grains of cassiterite, up to 0.5 mm in diameter, in a microcline-quartz biotite pegmatite cutting gneiss, 3.2 km northwest of Wilmot Pass.

**Wakaputa Point, Longwoods:** Very rare grains of cassiterite occur in a granite pegmatite at Wakaputa Point, in the Longwood Complex (Challis and Lauder, 1977).

### Placer deposits

**West Coast:** Detrital cassiterite is widespread in the West Coast region, as “stream tin” and in trace amounts in Quaternary alluvial gravels (Morgan, 1911, 1927; Henderson, 1917; Hutton, 1950; MacDonald, 1965; Nicholson, 1967; Bradley et al., 1979; Minehan, 1985, 1989). MacDonald (1965) and Minehan (1989) considered that the detrital tin was derived from erosion of tin mineralisation in granite, and Brathwaite and Pirajno (1993) suggested that the likely source was the greisen tungsten-tin deposits of the West Coast region.

Morgan (1911) noted cassiterite in the gold sluicing concentrates at Montgomery’s and neighbouring claims in the Blackball-Healy’s Gully district. One non-magnetic fraction (91.2%) of sluice box concentrate comprised 42.3% cassiterite, equivalent to 33.3% metallic tin. Morgan also identified stream tin in auriferous gravels near the coast line north of Ten Mile Creek.

Henderson (1917) reported sparse amounts of cassiterite in the Blacksand, Slaty and Ten-Mile creeks (Waihero district), and noted that a sample from Healy’s Gully gold sluicing claim contained 1.05% tin. Morgan (1927) listed occurrences of detrital cassiterite in the Mokihinui, Waimangaroa, Buller, and upper Grey rivers, Canoe Creek (north of Barrytown) and Humphrey’s Gully (Arahura Valley).

Hutton (1950) confirmed and extended these occurrences and recognised cassiterite in dredge concentrates from the Barrytown, Blackball, Snowy River, Grey River, Ngahere, Atarau, Arahura, Rimu, Kaniere and Slab Creek gold dredges. Nicholson (1955) estimated that 0.8 t of cassiterite was discharged in tailings from the Ngahere dredge each week.

Spectrographic studies of West Coast beach sands by Nicholson (1967) established low concentrations of tin in samples from Waimangaroa, Barrytown and Ross (generally 0.0002–0.01% of the original sand). Systematic exploration by Carpenteria Exploration Ltd, of the West Coast beaches for mineral sand, identified trace levels of cassiterite at

Birchfield, Westport (Zuckerman, 1972), Hokitika North (Painter, 1972a), Hokitika (Painter, 1973) and Hokitika South (Painter, 1972b).

**Fiordland and Southland:** Detrital cassiterite has been reported in Tertiary marine sandstone exposed in low cliffs about 400 m west of Stony Point, Lake Manapouri (Hutton and Turner, 1936), in beach sand on Pomona Island in Lake Manapouri (Willett, 1940), in Wet Jacket Arm in Dusky Sound (Morgan, 1927) and in a Holocene beach placer near Waiau Mouth (Nicholson, 1969).

**Stewart Island:** In the Port Pegasus area, cassiterite is associated with gold in small stream and eluvial gravel deposits on the flanks of the Tin Range (McKay, 1890; Williams, 1934a; Howard, 1940; Williams and Mackie, 1959). The cassiterite is derived from a greisen zone on the crest of the Tin Range. Heavy mineral concentrates of the alluvial deposits contain magnetite, cassiterite, garnet, wolframite, monazite, gahnite, epidote, topaz, zircon, rutile and gold (Williams, 1934a). The placers were worked intermittently from 1888 until 1914, producing small quantities of tin concentrate and gold.

## Past Production and Resources

About one tonne of alluvial tin concentrate was produced from the Port Pegasus area on Stewart Island between 1888 and 1894.

There are no identified resources in New Zealand, although prospecting in the early 1980s located low-grade tin-tungsten mineralisation at Falls Creek Hill near Ross. There is potential for limited production of tin as a coproduct of placer gold mining in the West Coast region.

## Future Trends

Shaw (1995) noted a decreasing demand for tin plate because of substitution by aluminium, plastics and tin-free steel for use as containers. However, an increase in the use of tin in solders may help to maintain demand for tin. This will be reliant on renewed investment in the construction and automobile sectors, because although there has been a dramatic expansion in the demand for electrical appliances, it has been offset by miniaturisation and increasingly efficient soldering techniques, especially in computers.

Environmental factors may restrict the use of tin chemicals which are used as biocides in anti-fouling paints. However there will be increased use of tin chemicals in fire retardants.

Projected increased demand for tin in the next few years can probably be accommodated by existing operations and reopening of others closed over the last 10 years. It is unlikely that there will be new investment in the exploration for tin deposits in the immediate future.

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