

**Mineral Resources Tasmania**  
**Mt Bischoff Mine Remediation Project**  
**Geology Report**

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### APPENDIX 1 - Mineralogy

PLAN 1      Mt Bischoff Mine Site Remediation Geology, 1:2000 Orthophoto

## SUMMARY

**The main historic workings at Mt Bischoff occur on three topographic levels ranging from approximately 630 - 700 metres RL. On the lower and middle levels large areas, comprising mainly sulphidic rock materials with high acid generating potential and low mining heritage and geoconservation values, have been mapped. These areas are well suited to landscaping and rehabilitation, with consideration needed for preserving some material for mineral specimen collectors.**

**Most of the high quality mining heritage and tin geology sites occur on the upper level, coincident with a low proportion of highly sulphidic rock. This upper level has excellent potential to be developed as a field education and tourism asset. Within this area there are sites requiring public safety barriers and some bodies of high sulphide mineralisation.**

**Several dangerous open shafts and several sources of major acid drainage, all of which need sealing, were identified and mapped.**

**Some fresh, acid - reactive dolomite outcrops around the workings but it does not represent a significant resource of neutralising material for the project. The optimum source of such material appears to be crushed Gordon Limestone from Lynchford, near Queenstown, backloaded to Waratah by truck.**

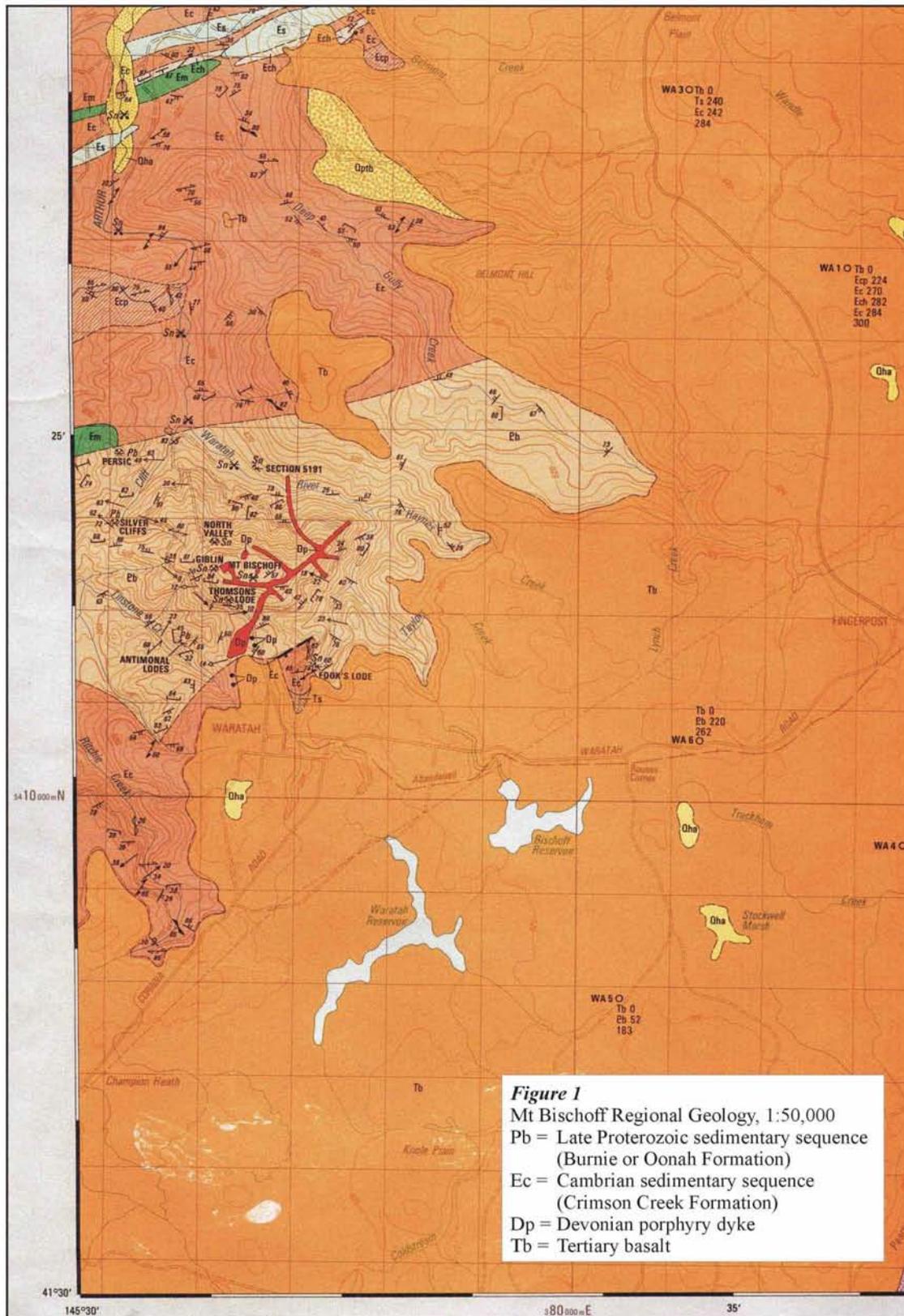
**Substantial quantities of basalt soil, clay and weathered rock are available for sale from private land bordering Waratah. A deposit of siltstone soil and clean regolith, at the southern end of the workings, is suitable for quarrying and use in the remediation. Contamination by broom, gorse and blackberry seed will be an issue for most soils sourced near Waratah.**

## INTRODUCTION

Mineral Resources Tasmania are conducting the Mt Bischoff Remediation Project, with the primary aim being to reduce the acid and metal loading draining from abandoned mine workings into the Arthur River.

Mt Bischoff is a world famous location for certain styles of tin mineralisation and there is a well preserved mining heritage, dating back to the 1870s, over parts of the mineral field. Consequently, there is an opportunity to remediate the site in a way which achieves the primary aim and at the same time leaves a significant tourism and educational asset for the community.

A team of specialists in various environmental, engineering and earth science fields has been assembled to undertake the project. K C Morrison Pty Ltd was engaged to conduct the initial field survey; involving rock chip sampling for a base line geochemical data set and a mapping program to delineate important sites and zones relevant to the remediation design work. This report covers the results of the mapping. Fifty four rock chip samples have previously been submitted to Mineral Resources Tasmania for analytical work.



## **SCOPE**

This mapping survey covers the main area of historic workings on Mt Bischoff (Figure 1, Plan 1). Additional workings and mill sites, some of which will be incorporated into the remediation, exist on the northern and southwestern slopes of Mt Bischoff but they are largely covered with regrowth vegetation and therefore are not suitable for 1:2,000 scale mapping.

The aims of the mapping survey were to:

- 1 delineate areas of both high acid generating potential and high preservation potential.
- 2 identify problem sites with respect to acid drainage and human safety.
- 3 identify sites with outstanding exploration and mining heritage or geoconservation value.
- 4 identify exposures of carbonate rock with acid neutralising properties.
- 5 locate sources of earth materials suitable for use in the remediation earthworks.

A detailed map of the site geology was produced by Groves (1972) in the Tasmania Department of Mines Geological Survey Bulletin No 54.

## **GEOLOGY OF THE MT BISCHOFF AREA**

The geology of the Mt Bischoff region (Figure 1) is dominated by a suite of Late Proterozoic (Burnie or Oonah Formation) to Cambrian (Crimson Creek Formation) relatively unmetamorphosed siltstone, sandstone shale and dolomite, locally intruded by Devonian granitic dykes and partially covered with an extensive sheet of Tertiary basalt.

The mineralisation is controlled by a swarm of Devonian porphyritic granite dykes (Figure 1) at their intrusive contacts with dolomite horizons within the Burnie Formation. Three styles of mineralisation are recognised.

- Stratiform replacement of dolomite horizons by massive sulphide containing cassiterite
- Altered porphyry dykes enriched in topaz, cassiterite and disseminated sulphide
- Fractures and fault fissures mineralised with vein quartz, sulphide and cassiterite.

The dolomite replacement style accounts for the majority of the high sulphide ore and is therefore the major source of acid mine drainage.

Mt Bischoff is one of a series of major world class tin-tungsten deposits in NW Tasmania, sourced from Devonian granite magmatic fluids reacting with alkaline carbonate rocks. Other ore bodies in this series include; Renison Bell, Mt Cleveland and Bold Head/Dolphin on King Island.

Peripheral to the central development of tin ore bodies at Mt Bischoff, are several smaller lead-zinc and antimony occurrences, some of which have been mined.

A thorough coverage of the geology, geochemistry and mining history of Mt Bischoff is given by Groves et al, 1972, Halley, 1987 and 1995 and Tasmania Department of Mines, 1989.

## **MAPPING RESULTS**

### *1. Acid Generation versus Heritage Value*

The historic mine workings are spread over three roughly defined topographic levels, centred on the 630, 650 and 700 metre RLs (Plan 1). In broad terms, the mapping attempted to separate zones and spot locations dominated by acid generating rocks and drainage, from zones and spot locations characterised by high heritage and geoconservation value.

Plan 1 shows that the 630 and 650 m RL levels (Photo 1) are predominantly occupied by acid generating rocks with low heritage value, apart from the good examples of open stopes in the Greisen Face, on the central western side of the workings. The high sulphide materials which are prevalent in Allens Workings, Gossan Face, Greisen Face, White Face and Pig Flat consist of heavily mineralised and gossanous dolomite. This is volumetrically the major ore type exposed in the historic workings, and because of its high total sulphide and diverse sulphide species mineralogy, it would have been metallurgically more difficult to treat than the dyke and fissure ore types.

Parts of the lower and middle levels of the workings have been disturbed and degraded in recent years by small scale mining, fill and gravel quarrying and drainage earth works. The large flat area at the base of the Greisen Face (Photo 1) is the result of rehabilitation after road gravel quarrying. Apart from the abundance of material attractive to mineral specimen collectors, those areas would clearly be improved by landscaping and rehabilitation.

Peripheral to the main group of workings, additional areas of high acid generating potential/low conservation value were mapped around the NE Lodes, North Face and downslope from the top Mt Bischoff Extended adit (Plan 1).

The geology of the upper (700 m RL) level includes high sulphide dolomite replacement mineralisation in the Slaughter Yard Face and in the Brown Face pit, but predominantly consists of porphyry dykes intruding siltstone (Photo 2). There is a striking contrast between the extensive sulphide development at porphyry-dolomite contacts, compared to the lack of sulphide at porphyry-siltstone contacts.

Several quality heritage and geoconservation sites are preserved around the 700 m RL level (Table 1) and the whole area is ideal for development as an educational/tourism destination.

Large parts of the Brown Face, Slaughter Yard Face and Greisen Face are characterised by both acid generating rocks and good examples of mining methods and tin geology (Plan 1). Dangerous open shafts, stopes and steep drops into the Brown Face open cut need barrier fencing if they are to be preserved and incorporated into sites for public viewing. They certainly appear to be worth



*Photo 1* Looking south over Greisen Face, Gossan Face and Allens Workings, from the 700m RL access road to Slaughter Yard Face.



*Photo 2* Looking southeast over Desert Face to Stanhope Face, from the 700m RL northeast of the Brown Face open cut.

Table 1  
Important Mining Heritage and Geoconservation Sites

| No | GPS Co-Ords           | Type           | Description   |
|----|-----------------------|----------------|---|
| 1  | 376,724 E 5,412,037 N | Mining         | A small locally built mill with heritage equipment. It needs to be shifted and restored.  |
| 2  | 376,469 E 5,412,184 N | Mining         | Good examples of open stopes in massive dolomite replacement ore. The site is dangerous and needs safety barriers for public viewing.                             |
| 3  | 376,504 E 5,412,314 N | Geology        | A good site to study and sample high grade dolomite replacement ore in relative safety.   |
| 4  | 376,575 E 5,412,281 N | Geology        | The best example seen of low sulphide mineralisation and hydrothermal brecciation on a porphyry dyke contact.   |
| 5  | 376,570 E 5,412,301 N | Mining         | A narrow lode stope held open with well preserved timbers. A safety barrier is needed for public viewing.   |
| 6  | 376,648 E 5,412,268 N | Mining/Geology | Conveyor remains and their footings, with abundant mineralised porphyry specimen material nearby.   |
| 7  | 376,788 E 5,412,325 N | Mining         | A well preserved sluicing dam with stone wall, in the floor of hand mined hard rock quarry developed on a porphyry dyke.  |
| 8  | 376,877 E 5,412,354 N | Lookout        | The best lookout site for a panoramic view of Waratah and the wider NE to SE region.  |
| 9  | 376,586 E 5,412,390 N | Mining         | A well preserved explosives magazine.   |
| 10 | 376,532 E 5,412,409 N | Lookout        | The ideal site for a Brown Face pit lookout. This is the largest pit on the field but there are safety issues for both the access track and the viewing platform. |
| 11 | 376,630 E 5,412,460 N | Mining/Geology | A large pit on dolomite replacement ore, with some mining gear visible. A safety barrier is needed for viewing.   |
| 12 | 376,704 E 5,412,578 N | Mining/Lookout | The best preserved conveyor remains on the field, with view over North Valley and the Waratah River.  |
| 13 | 376,328 E 5,412,572 N | Geology        | A good exposure of the complex geometry at a dyke contact, including specimens.   |

preserving and the Slaughter Yard Face area has perhaps the best close range exposures of dyke contacts and dolomite replacement ore on the entire field (Photo 3).

## 2. *Dangerous Sites*

In addition to the open stopes and shafts with mining heritage value, as discussed above, Plan 1 shows five shafts which are on the edge of access tracks through the upper mine level. These sites are dangerous and need sealing, which in addition to rendering the sites safe would reduce oxygen flow into subsurface mineralisation, and should therefore reduce acid drainage outflow. A hexagonal shaft (376,625 E, 5,412,275 N) may be worth preserving and if so will need a barrier fence.

## 3. *Acid Mine Drainage*

Five streams of major AMD emanating from adits and one from a drill collar at ground level were recognised during the mapping (Plan 1). An additional major AMD stream is flowing into the Waratah River, from a spring, adjacent to the old mill site in North Valley, west of Websters Creek and north of the area mapped (376,370 E, 5,413,393 N). There may be other major sources, from workings under regrowth in North Valley and along Tinstone Creek, as these areas were not included in the mapping area. In addition, there are undoubtedly numerous lower grade sources of acid drainage with less visual expression than those mapped to date. These occurrences will be dealt with in a more comprehensive report on drainage throughout the project area.

## 4. *Sources of Acid Neutralising Rock*

Some fresh dolomite is preserved at Mt Bischoff, despite the fact that the most intensive sulphide mineralisation is due to the reaction of hydrothermal fluids with the dolomite (Photo 4). The main areas of outcropping fresh dolomite are shown on Plan 1. These rocks are mainly totally unaltered - they effervesce moderately in 20% HCl (providing the rock surface is scratched and powdered), so they will be exerting some neutralising effect on the acid drainage. Unfortunately most of the dolomite is silicified or partly - entirely replaced by sulphide and iron-manganese oxides (gossan) and would be completely non alkaline. There is no useful resource of fresh dolomite available at the surface for rehabilitation, so there is a need to import crushed carbonate rock. Magnesite is potentially available from the Savage River iron ore mine, 30 km southwest of Waratah, but a crusher would have to be set up at Savage River and the magnesite is clearly inferior to high grade limestone for reducing acidity.

High grade Ordovician limestone (Gordon Limestone or Flowery Gully Limestone) is available crushed and sized from; Queenstown, Railton, Mole Creek and Winkleigh. A back loading opportunity exists for the Queenstown source. Copper Mines of Tasmania are currently buying crushed rock from a quarry near Waratah, to use as stope backfill at Mt Lyell. Joe Fagan Heavy Haulage Pty Ltd is trucking this rock to Mt Lyell and currently returning empty. They estimate a transport cost of \$4/tonne to backload crushed limestone from Lynchford, about



*Photo 3* Hydrothermal breccia texture at a porphyry dyke-siltstone contact, 700m RL level access road near Slaughter Yard Face.



*Photo 4* Remnant of fresh dolomite outcrop at the base of Greisen Face

5 km south of Queenstown, so this would be the cheapest source. There is some uncertainty about the time span of this opportunity as it depends on the renewal of the existing trucking contract by CMT.

#### 5. *Sources of Clay Capping and Rehabilitation Material*

Two privately owned sources of basalt soil, clay and weathered rock were identified on the outskirts of Waratah (377,145 E, 5,409,767 N and 376,413 E, 5,409,086 N). Both sources are available for sale and the material looks to be physically ideal for capping and have high fertility. A problem with this material (and this is a widespread problem around Waratah) is the prevalence of the weed plants broom, gorse and blackberry. Use of this material would introduce weed seed to the rehabilitation so a weed spraying program would be needed.

A source of siltstone soil and regolith is located on a small, lightly vegetated hill between Allens Workings and the Don Hill Workings (Plan 1). This area is relatively free of weeds and could easily be rehabilitated after about 4 metres of material is stripped from the hill.

#### 6. *Mineral Specimens*

The entire area of the Mt Bischoff workings is renowned for its abundance and diversity of mineral specimens and access to material for collectors and fossickers will be reduced by remediation earth works. MRT mineralogist Ralph Bottrill provided the list of known mineral species sourced from Mt Bischoff, attached in Appendix 1.

It should be possible, by landscaping, to preserve some mounds of the gossanous dolomite replacement material, which is the richest source of specimens, on the lower and middle levels without significantly compromising the reduction of acid drainage.

### **REFERENCES**

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# Appendix 1

## MINERALOGY

More than 100 mineral species have been recorded from Mt Bischoff, particularly because of the extensive alteration and large amounts of magnesium and fluorine in the system, producing uncommon minerals such as sellaite, chondrodite, norbergite, wagnerite and fluoborite.

*Beryl:* Pale to mid-blue, opaque crystals of beryl up to 5cm in length occur at Mt Bischoff, especially near the Slaughteryard Face, associated with an emerald green tourmaline. Some of these crystals exhibit colour zoning which can be seen on the flat terminations of the hexagonal prisms. Other beryllium minerals recorded from Mt Bischoff include bavenite, hambergite and phenakite.

*Carbonates:* The major carbonate present is commonly referred to as siderite, but most appears to be a Fe-magnesite, except in more quartz-rich rocks. Generally the lighter the colour of the specimen, the less iron content. Rhodochrosite is rare here. Most siderite/magnesite is found as tabular hexagonal crystals to 5cm across and is common in the dolomite replacement bodies, often associated with fluorite.

*Cassiterite:* Cassiterite was the most important tin mineral mined at Mt Bischoff. It occurs in a number of environments, and was particularly abundant in the dolomite replacement bodies (especially the White and Brown faces). Much of the cassiterite mined was eluvial or alluvial, released through weathering processes. In 1880, a 5 cwt solid nugget was recovered from the Slaughteryard Face. It is still possible to pick up masses of cassiterite up to 6cm with bright euhedral crystals in cavities. Bright red-brown, yellowish or black crystals to 3mm can be found lining joints in the dyke rocks and sedimentary rocks adjacent to the dykes. Crystalline cassiterite generally occurs as short, equant prisms, often twinned, or rarely acicular crystals to about 1mm. Stannite and teallite are the other tin minerals recorded here.

*Fluorite:* This is abundant in many parts of the mine, particularly the dolomite replacement bodies and veins, especially in the Slaughteryard Face. It is found mostly as cubes to 3cm, modified by octahedral (111) and to a lesser extent, dodecahedral (110) faces on a matrix of either magnesite or siderite. Most specimens are transparent lustrous crystals, either colourless or pale blue, but massive purple fluorite also occurs. Nearby some brown octahedral fluorite occurs in cellular quartz-topaz-sellaite. In the late 1980s, part of the Happy Valley Face was worked for specimen material: transparent colourless crystals of fluorite, almost always as cubes, sometimes elongated or flattened, occurring on Fe-magnesite.

Associated minerals included quartz, pyrite and sphalerite. Green fluorite, sometimes with purple cores, has been found near the White Face dyke in recent years. Near the gossan face dark purple fluorite occurs as complex cubo-octahedral crystals with tourmaline, siderite, pyrite, marcasite and smoky quartz. Other fluoride minerals identified include sellaite, prosopite, ralstonite and weberite.

*Quartz* - Abundant small, white to colourless quartz crystals occur in the porphyry dykes and in other areas such as the Happy Valley Face, occasionally as wheatsheaf aggregates. Smoky quartz specimens to 4 cm are much less common but very aesthetic, occurring with purple fluorite and siderite crystals. Sulphides - Pyrite and pyrrhotite are ubiquitous. Pyrite can occur as attractive crystals, often as cubes or less commonly pyritohedrons and other forms. Some does decompose however. Other sulphides found in crystalline form include arsenopyrite, marcasite and sphalerite.

*Topaz* - The porphyries contain a compact fine-grained form of topaz known as pycnite, found as pseudomorphs after feldspar, and as radiating groups of transparent acanthine crystals to 2mm. Coarser crystals are rare.

*Tourmalines* - Tourmaline is common at Mt Bischoff, generally as blue to green masses or thin tufted acicular crystals and rarely as very fine-grained botryoidal masses. Compositions range between dravite, schorl, olenite and foitite. Elbaite has also been reported but not confirmed.

## **Minerals Reported**

*Native elements:* arsenic, bismuth, copper, gold, graphite, sulphur.

*Sulphides:* arsenopyrite, berthierite, bismuthinite, boulangerite, chalcocite, chalcopyrite, galena, jamesonite, marcasite, molybdenite, proustite, pyrargyrite, pyrite, pyrostilpnite, pyrrhotite, sphalerite, stannite, stibnite, teallite, tetrahedrite.

*Oxides:* brucite, cassiterite, chromite, corundum, cuprite, diaspore, gahnite, goethite, hematite, magnetite, pyrolusite, rutile, thorianite, tungstite.

*Halides:* bodalyrite?, fluorite, halite, prosopite, ralstonite, sellaite, weberite, sylvite.

*Carbonates:* ankerite, aragonite, azurite, calcite, dolomite, magnesite, malachite, rhodochrosite, siderite, smithsonite.

*Sulphates:* barite, chalcantite, copiapite, goslarite, gypsum, halotrichite, jarosite, melanterite.

*Silicates:* actinolite, albite, allanite, andradite, annite, augite, bavenite, beryl, biotite, chondrodite, chrysotile, clinocllore, clinohumite, dravite, elbaite, enstatite, epidote, foitite, forsterite, hemimorphite?, hisingerite, hornblende, hydrogrossular, illite, kaolinite, lepidolite, lizardite, microcline, muscovite, natrolite, norbergite, olenite, opal, orthoclase, palygorskite, phlogopite, pyrophyllite, quartz , schorl, sillimanite, talc, titanite, topaz, tourmaline, tremolite, vesuvianite, wollastonite, zircon.

*Phosphates and other:* Fluorapatite, hambergite, isokite, monazite, scorodite, scheelite, vivianite, wagnerite, wavellite, wolframite (ferberite), xenotime.