Mineral systems in the Gascoyne Complex, Western Australia

by

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Mineral systems studies in the Gascoyne Complex (Fig. 1) are being integrated with geological mapping, to construct descriptive and genetic models of ore systems and delineate prospective tracts. Building a mineral-system genetic model allows a degree of predictability that can assist in exploration targeting. In this contribution, preliminary results of these field-based studies, commenced in the 2007 field season, are reported.

Gascoyne Complex

The Gascoyne Complex records a series of tectonic and thermal events involving deformation, metamorphism, and granite intrusions. Details of the geology of the complex can be found in Martin et al. (2006) and Sheppard et al. (2007) and overviews of its mineralization in Flint and Abeysinghe (2000), and Hassan (2007).

Mineral systems

The following mineral systems have been examined on the MANGAROON*, EDMUND, MOUNT PHILLIPS, and EUDAMALLAH 1:100 000 map sheets (Fig. 1):

- Tungsten (scheelite) skarns (Nardoo Well)
- Rare metals (Ta, Bi, Be) and uranium in pegmatites (Morissey Hill and Mortimer Hill fields)
- Molybdenum–copper–tungsten occurrences in shear zones (Minnie Creek batholith)
- Polymetallic quartz veins (Mangaroon field)
- Carbonatite-related rare earth elements (REE) and uranium (Gifford Creek Complex)

Tungsten and magnetite skarns at Nardoo Well

Near Nardoo Well, calc-silicate layers along the southern margin of a tourmaline–biotite–muscovite granite pluton form ridges trending east-southeast, parallel to the Ti Tree Shear Zone. Calc-silicate rocks are cut by epidote and tourmaline veins and quartz stockworks. Scheelite mineralization is in the quartz stockworks. The calc-silicate layers were formed by thermal metamorphism of Ca-rich rocks at the southern contact with the tourmaline-rich granite and the contained scheelite mineralization may represent a distal skarn system. If correct, this may have important implications, because proximal skarns (pyrrhotite, magnetite, gold and Cu–Pb–Zn sulfides) could be present downdip, closer to the deeper granite contact.

Pegmatites

Pegmatites are abundant in the area examined, most having been exploited for muscovite and beryl. Some pegmatites are known to have uranium and tantalite–columbite mineralization (Flint and Abeysinghe, 2000). These pegmatites are generally zoned, with a quartz core. Others consist of feldspar–quartz–muscovite intergrowths. Some of the more common minerals of the pegmatites include albite, almandine, apatite, beryl, bismuthinite, native bismuth, chrysoberyl, elbaite, ferrocolumbite, tantalite, lepidolite, uraninite, uranophane, pyrochlore, and xenotime. Sheppard et al. (2007) suggested that these pegmatites may have originated from unexposed or as yet unrecognized c. 950 Ma plutons.

Mo–Cu–W–Pb intrusion-related mineralization

Copper–Pb–Mo and Mo–Cu–W prospects are located within a corridor defined by the Ti Tree Shear Zone, which affects granitic rocks of the Minnie Creek batholith (Fig. 1). The Minnie Creek batholith (see figure 1, Sheppard et al., this volume, for extent of batholith) is part of the 1830–1780 Ma Moorarie Supersuite (Martin et al., 2006). In the area examined, the main rock type is a biotite monzogranite. The Ti Tree Shear Zone is characterized by strongly foliated porphyritic granite, which is almost pervasively altered to a quartz–sericite(–chlorite) assemblage that overprints the penetrative foliation in the shear zone.

* Capitalized names refer to standard 1:100 000 map sheets, unless otherwise indicated.

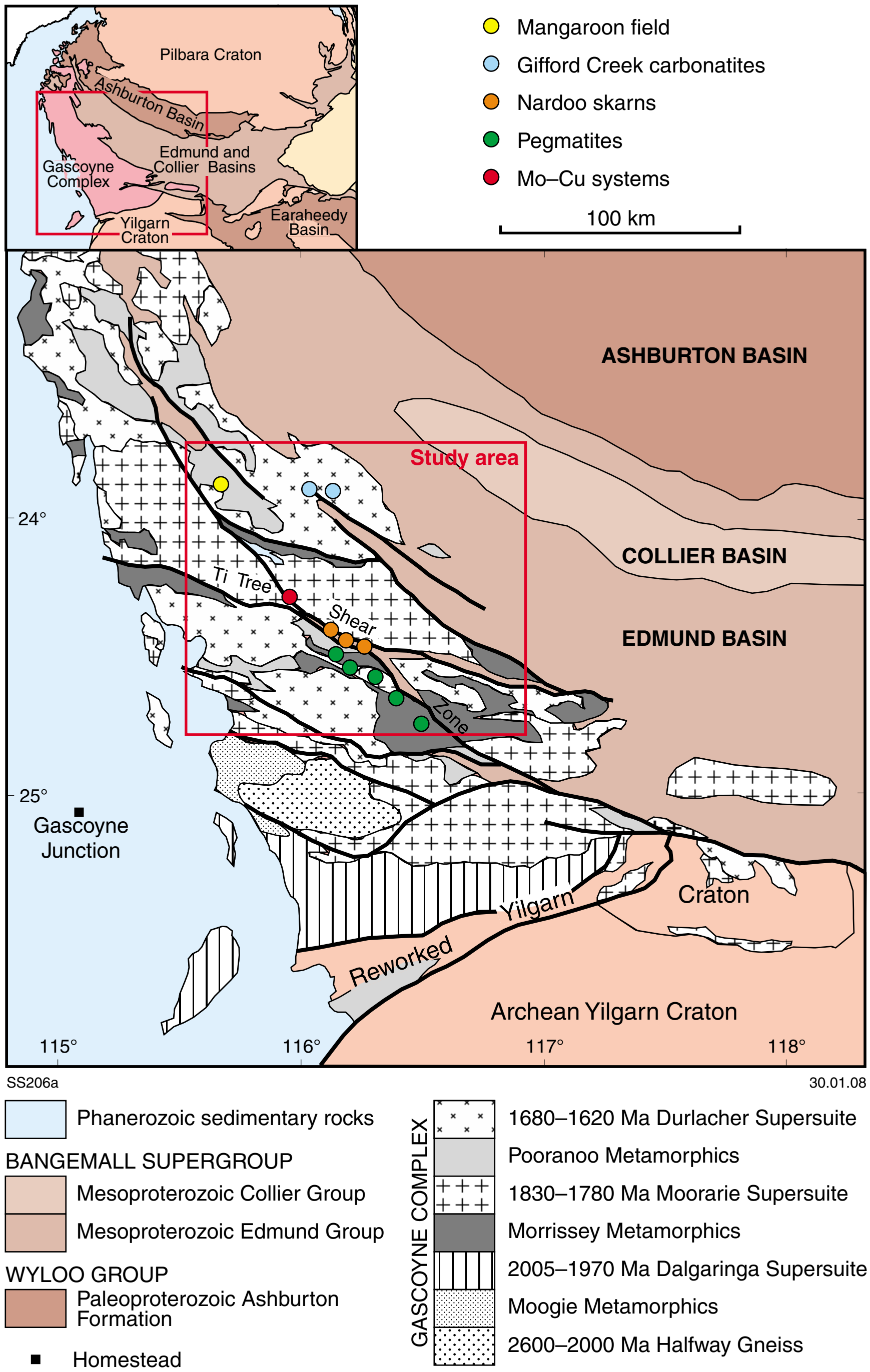

Figure 1. Simplified geology of the Gascoyne Complex; inset shows area investigated (after Sheppard et al., 2007)

At the Minnie Springs Mo–Cu prospect there are two mineralization styles: one is disseminated molybdenite in a pervasively potassic-altered granite; the other consists of molybdenite-bearing quartz veins and veinlets hosted in sericitized foliated granite. Re–Os dating of disseminated molybdenite yielded an age of c. 1770 Ma (S Sheppard, unpublished data). Two zones of mineralization are recognized: a Mo zone and a W–Cu zone, each with a strike extent of about 4 km. The Mo zone is associated with potassic alteration, the W–Cu zone is associated with quartz–sericite alteration.

Based on field and petrographic evidence, it is suggested that granitic pluton of the Minnie Creek batholith developed Mo mineralization, possibly in its roof zone. This was followed by deformation that resulted in the penetrative foliation of the southeast-trending Ti Tree shear zone. Hydrothermal fluids were channelled along the shear zone, causing formation of quartz veins and redistribution of the pre-existing molybdenite in these veins. Continuing hydrothermal activity formed southeast-trending, thick and barren quartz veins, which being more resistant to erosion now form the high ground at the Minnie Springs prospect. The youngest generation of fractures and quartz veins, which cut through all fabrics and previous veins, trends 020º, is parallel to mafic dykes, and is locally mineralized. An initial assessment of these prospects indicates that they are not porphyry systems, but rather the result of a hydrothermal fluid flow that was channelled along the Ti Tree Shear Zone, as the alteration patterns and the lack of stockwork veins do not conform with porphyry systems indicators.

Mangaroon polymetallic quartz veins

The Mangaroon mineralization consists of quartz veins containing varying amounts of sulfides (galena, chalcopyrite) as well as Au and V minerals. The veins are hosted by rocks of the c. 1680 Ma Pooranoo Metamorphics and granitic rocks of the c. 1675 Ma Pimbyana Granite. At Mangaroon and Mangaroon South, the ore veins strike ~20° with shallow dips (~20° northwest), whereas at Two Peaks Mangaroon a sheeted vein system, emplaced in Pimbyana Granite, has a general attitude of 300° with steep dips to the northeast (~50°). The Mangaroon veins have features that are transitional between mesothermal and epithermal mineral systems. There is no visible hydrothermal alteration of the wall rocks, suggesting that the Mangaroon polymetallic veins were formed as a result of regional-scale hydrothermal fluid flow, perhaps associated with a post-orogenic extensional event.

Gifford Creek Complex

The high-level alkaline Gifford Creek Complex was first recognized and studied by Pearson et al. (1996). The complex is represented by a swarm of west-northwest-trending lamprophyric sill-like and dyke intrusions, located along the Lyons River lineament, and dykes and sills of carbonatitic affinity. A poorly constrained age of c. 1680 Ma for the complex was suggested by Pearson et al. (1996). Extensive fenitization accompanies these intrusions and affects the granite of the Durlacher Supersuite. The Lyons River lamprophyric rocks contain olivine phenocrysts set in a fine-grained matrix consisting of apatite, barite, monazite, phlogopite, K-feldspar, and Fe oxides. The carbonatitic rocks, which are associated with numerous ironstone and quartz veins, consist of Fe-carbonates, magnetite, phlogopite, allanite, apatite, pyrite, sodic amphibole, aegirine, and trace amounts of molybdenite, sphalerite, and galena. The ironstones consist of hematite and magnetite with minor amounts of calcite and dolomite.

Rare earth and uranium mineralization has been recorded in the carbonatite and ironstone veins (Flint and Abeysinghe, 2000). For the Gifford Creek carbonatites, Flint and Abeysinghe (2000) quoted estimated total resources of about 2.77 Mt, averaging 1.52% REE oxides. Most of these occurrences consist of sinuous veins of predominantly Fe oxides that intrude porphyritic granites of the Durlacher Supersuite. These veins have margins of Fe-rich carbonates associated with zones of alteration that have fenitic haloes, characterized by the presence of feldspars, amphiboles, and magnetite. A tentative model, based on field and petrographic observations, suggests that fenitization occurred after the emplacement of carbonatite; this was followed by lower temperature hydrothermal activity, during which dissolution of iron (?magnetite) and REE primary minerals took place. An initial stage of this hydrothermal activity produced quartz–sericite–phlogopite and a later stage of hematite–goethite–quartz, which now constitute most of the outcropping veins.

Concluding remarks

The mineral systems examined, except for the c. 1770 Ma Minnie Springs disseminated molybdenite, are associated with thermo-tectonic events that post-date the Capricorn Orogeny and even perhaps the Mangaroon Orogeny, as some mineralized veins cut fabrics of Mangaroon Orogeny age. A thermo-tectonic event between 1030 and 950 Ma that affected the Gascoyne Complex may have produced the intrusions of tourmaline-bearing granites and pegmatites. It is possible that this late event is anorogenic and that the skarns, the REE-bearing veins, and the late phases of the Mo–W mineralization along the Ti Tree Shear Zone are associated with this event. Although this hypothesis needs to be tested by isotopic age determinations, the Ti Tree Shear Zone can be considered a highly prospective tract. Whereas magmatic links are certain for the W and magnetite skarns, the Morrissey Hill and Mortimer Hill pegmatite fields, and the carbonatite REE, such a link is less certain for the Mangaroon polymetallic ore field, where Au-bearing vein systems strike 010°–020° (Star of Mangaroon), cut through all fabrics, and post-date the 755 Ma Mundine Well Dolerite Suite (Martin et al., 2006). This is the youngest recognizable event, which may be associated with far-field tectonic processes that post-date the 755 Ma intraplate magmatism.

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