Recent advances in our understanding of the Gascoyne Complex

by

S Sheppard, SP Johnson, PB Groenewald, S Bodorkos[1], B Rasmussen[2], IR Fletcher[2], JR Muhling[3], and K Selway[4]

Introduction

The Gascoyne Complex is located at the western end of the Proterozoic Capricorn Orogen, which is a major tectonic zone separating the Archean Yilgarn and Pilbara Cratons (see inset to Fig. 1). Early models for the evolution of the complex emphasized vertical movements of the crust rather than plate tectonic processes (e.g. Williams, 1986). These ideas were supplanted in the late 1980s and 1990s by tectonic models that invoked subduction and collision between the Pilbara and Yilgarn Cratons during the Capricorn Orogeny (Muhling, 1988; Tyler and Thorne, 1990). A program of remapping and SHRIMP U–Pb geochronology in the complex has shown that elements of both models are correct: plate tectonic processes resulted in a collision between the Yilgarn and Pilbara Cratons (probably during the 2000 to 1950 Ma Glenburgh Orogeny), but the complex also records a prolonged history of intracontinental reworking.

Tectonic evolution of the Gascoyne Complex

The Gascoyne Complex comprises several zones (Fig. 1), and although each is characterized by a distinctive and episodic history of deformation, metamorphism, and granitic magmatism, only the Errabiddy Shear Zone juxtaposes exotic terranes.

The oldest crust in the Gascoyne Complex is the Glenburgh Terrane, which is exposed in the Paradise and Mooloo zones in the southern part of the complex. The Glenburgh Terrane comprises granitic rocks with igneous crystallization ages of between 2660–2470 Ma and c. 2000 Ma (Halfway Gneiss), psammitic and pelitic rocks of the Moogie Metamorphics deposited after c. 2300 Ma, and a 2005 to 1970 Ma granitic batholith (Dalgaringa Supersuite). The Halfway Gneiss is unconformably overlain by the Moogie Metamorphics, which include relict pelitic migmatites, now pervasively retrogressed to chloritoid-bearing schists. The 2005 to 1970 Ma Dalgaringa Supersuite is interpreted to have formed above a northwestward-dipping subduction zone along the southern margin of the Gascoyne Complex. Collision with the passive margin of the Yilgarn Craton was marked by medium- to high-grade metamorphism during the later stages of the 2000 to 1950 Ma Glenburgh Orogeny, and followed by the intrusion of granites across the suture zone between 1960 and 1950 Ma.

Components of the Halfway Gneiss younger than c. 2610 Ma have no counterpart in the Yilgarn or Pilbara Cratons. Recent mapping and geochronology indicate that the Halfway Gneiss and Moogie Metamorphics may be present in the Mutherbukin zone (Fig. 1), an interpretation consistent with magnetotelluric survey results (Selway, in prep.), which suggest that the Glenburgh Terrane forms basement to the whole Gascoyne Complex. The survey also shows that the electrical character of the complex is unlike that of either bounding Archean craton, with the margins of the complex marked by the Errabiddy Shear Zone to the south and the Talga Fault to the north (Fig. 1).

Siliciclastic sediments (and minor mafic volcanic or high-level intrusive rocks) were deposited across the northern two-thirds of the Gascoyne Complex (Morrissey Metamorphics), and in the adjacent Ashburton Basin to the north and northeast, after c. 1840 Ma. These sedimentary packages were deformed and metamorphosed during the 1830 to 1780 Ma Capricorn Orogeny and intruded by voluminous granites of the Moorarie Supersuite, including those of the Minnie Creek batholith. The orogeny was probably responsible for recumbent folding and early high-grade metamorphism in the Mutherbukin zone. The Capricorn Orogeny may represent the far-field effects of plate collisions elsewhere in the supercontinent to which the West Australian Craton belonged.

[1] Onshore Energy and Minerals Division, Geoscience Australia, GPO Box 378, Canberra ACT 2601, Australia

[2] Department of Applied Geology, Curtin University of Technology, GPO Box U1987, Perth, WA 6845, Australia

[3] Centre for Microscopy, Characterisation and Analysis M010, The University of Western Australia, 35 Stirling Highway, Crawley, 6009, Australia

[4] Continental Evolution Research Group, School of Earth and Environmental Sciences, University of Adelaide, SA 5005, Australia

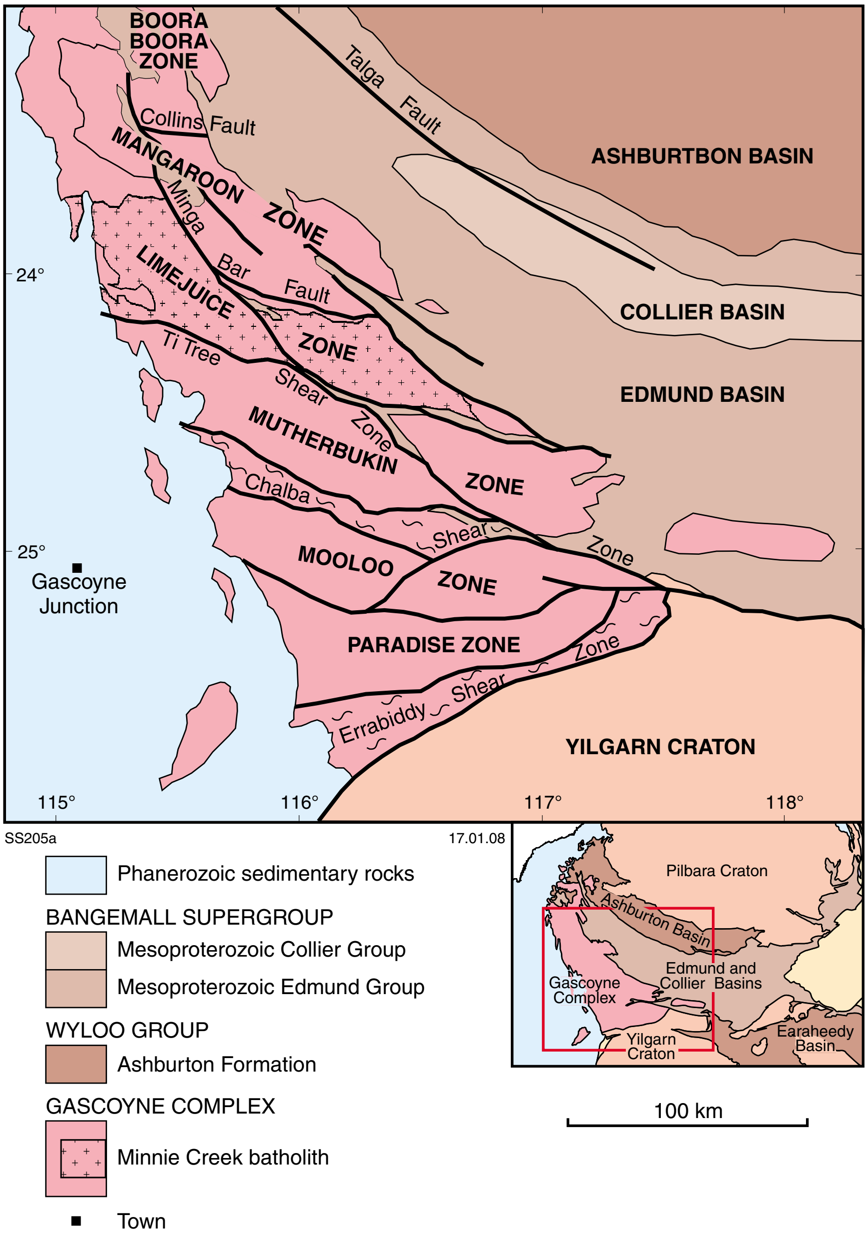

Figure 1. Structural metamorphic zones in the Gascoyne Complex. Also shown are the main shear zones and faults, including the Talga Fault, which is interpreted to mark the boundary between the Gascoyne Complex and Pilbara Craton. Inset shows the tectonic setting of the Gascoyne Complex

At about 1690 to 1680 Ma, siliciclastic sedimentary protoliths of the Pooranoo Metamorphics were deposited across the Gascoyne Complex. At the base, these comprise fluvial conglomerate and sandstone, and shallow-marine sandstone (Mount James Formation). In the northern part of the Mutherbukin zone, and in the Mangaroon zone, these rocks grade upwards into turbiditic sandstone, siltstone, and shale that appear to mark a deepening of the basin to the north. Rare amphibolite and calc-silicate rocks represent metamorphosed mafic–ultramafic extrusive or early high-level intrusive rocks. During the 1680 to 1620 Ma Mangaroon Orogeny, the Pooranoo Metamorphics underwent recumbent and then upright folding accompanied by low-P/high-T metamorphism in the Mangaroon zone and low-P/low-T metamorphism in the Mooloo and Mutherbukin zones. The complex, in particular the Mangaroon and Mutherbukin zones, was also intruded by voluminous granites between 1680 and 1620 Ma (Durlacher Supersuite). The Mangaroon Orogeny may be a response to plate reorganization and (micro-)continent collision along the southern margin of the combined North Australian – West Australian Craton.

Following the Mangaroon Orogeny, fine-grained siliciclastic sediments and carbonates were deposited in first the Edmund Basin and then the Collier Basin, both of which unconformably overlie the Gascoyne Complex. The complex was intruded by dolerite dykes that may be in part equivalent to the c. 1465 Ma dolerite sills in the Edmund Basin, and the c. 1070 Ma dolerite sills and dykes of the Warakurna large igneous province (Wingate et al., 2004). East-trending dolerite dykes in the Paradise zone may be a continuation of c. 1210 Ma dolerite dykes intruded into the northwestern Yilgarn Craton (Wingate et al., 2005).

Preliminary SHRIMP U–Pb monazite and xenotime dating in the Mutherbukin zone suggests that the main deformation and amphibolite facies low-P/high-T regional metamorphism took place between about 1280 Ma and 1200 Ma, and not during the Paleoproterozoic as previously supposed. Published SHRIMP U–Pb monazite and xenotime dating in the northern part of the zone indicates that greenschist to amphibolite facies regional metamorphism and deformation is related to the 1030 to 950 Ma Edmundian Orogeny (Sheppard et al., 2007). This tectonism was accompanied by intrusion of leucocratic granite plutons and rare-element bearing pegmatites at c. 950 Ma. Outside of this corridor, the Edmundian Orogeny was responsible for widespread folding and low-grade metamorphism of the Edmund and Collier Groups and, presumably, the Gascoyne Complex. The cause of tectonism during the Edmundian Orogeny is unclear.

At c. 755 Ma, the Gascoyne Complex and adjacent tectonic units were intruded by dolerite dykes of the Mundine Well Dolerite Suite. Within the Gascoyne Complex, this dyke suite is cut by a series of prominent east-southeasterly trending shear zones with dextral strike-slip kinematics, and in situ Ar–Ar dating of fine-grained white mica on the S-planes of an S–C fabric within the Chalba Shear Zone yielded a likely deformation age of 570 ± 10 Ma (Bodorkos and Wingate, 2007). The dextral shear zones represent an episode of intracontinental reactivation related to other 'pan-African' events in Gondwana.

Conclusions

The evolution of the Gascoyne Complex involves northward subduction and calc-alkaline magmatism at 2005 to 1970 Ma followed by collision of the complex with the Yilgarn Craton at between 1960 and 1950 Ma. The presence of the Morrissey Metamorphics on both northern and southern sides of the c. 1830 Ma Minnie Creek batholith precludes the batholith from 'stitching' the complex after collision of the Yilgarn and Pilbara Cratons during the Capricorn Orogeny as previously proposed. Instead, magnetotelluric data suggest that the boundary between the Gascoyne Complex and Pilbara Craton, which is now buried, corresponds to the Talga Fault. The Gascoyne Complex has a long and episodic history of intracontinental reworking and reactivation, in response to the far-field effects of interplate boundary forces.

References

Bodorkos, S, and Wingate, MTD, 2007, The contribution of geochronology to GSWA's mapping programs: current perspectives and future directions: Geological Survey of Western Australia, Record 2007/2, p. 10–11.

Muhling, JR, 1988, The nature of Proterozoic reworking of early Archaean gneisses, Mukalo Creek area, southern Gascoyne Province, Western Australia: Precambrian Research, v. 40/41, p. 341–362.

Selway, K, in prep., Magnetotelluric investigation into the electrical structure of the Capricorn Orogen, Western Australia: Geological Survey of Western Australia, Record 2007/16.

Sheppard, S, Rasmussen, B, Muhling, JR, Farrell, TR, and Fletcher, IR, 2007, Grenvillian-aged orogenesis in the Palaeoproterozoic Gascoyne Complex, Western Australia: 1030–950 Ma reworking of the Proterozoic Capricorn Orogen: Journal of Metamorphic Geology, v. 25, p. 477–494.

Tyler, IM, and Thorne, AM, 1990, The northern margin of the Capricorn Orogen, Western Australia — an example of an Early Proterozoic collision zone: Journal of Structural Geology, v. 12, p. 685–701.

Williams, SJ, 1986, Geology of the Gascoyne Province, Western Australia: Geological Survey of Western Australia, Report 15, 85p.

Wingate, MTD, Pirajno, F, and Morris, PA, 2004, Warakurna large igneous province: A new Mesoproterozoic large igneous province in west-central Australia: Geology, v. 32, p. 105–108.

Wingate, MTD, Morris, PA, Pirajno, F, and Pidgeon, RT, 2005, Two large igneous provinces in late Mesoproterozoic Australia: Geological Society of Australia, Abstracts v. 81, p. 151.