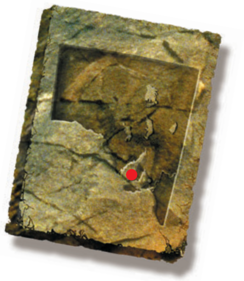

Age of the Kimban Orogeny revealed
— U–Pb dates on the Corny Point Paragneiss, Yorke Peninsula

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Introduction

The Palaeoproterozoic Kimban Orogeny (~1850–1700 Ma) has long been recognised in the eastern Gawler Craton and is best recorded on eastern Eyre Peninsula. Thomson (1969) and Parker (1993) considered that the orogeny also intensely deformed the Palaeoproterozoic granites and gneisses on southwestern Yorke Peninsula (Fig. 1). The data from this area are limited (Crawford, 1965; Golin, 1976; Pedler, 1976; Glen et al., 1977; Richardson, 1978; Webb et al., 1986; Rankin et al., 1991) because of relatively thick sedimentary cover and poor geophysical data. Basement gneisses on Yorke Peninsula were initially mapped as Archaean (Crawford, 1965) and subsequently described as the Palaeoproterozoic Lincoln Complex (Thomson, 1969; Parker, 1993).

Petrology, geochemistry and U–Pb geochronology of the Palaeoproterozoic magmatic Lincoln Complex rocks on southern Yorke and western Eyre Peninsulas indicate that they are correlated, but their relationship with the younger Wallaroo Group (cf. Conor, 1995) of the eastern Moonta Subdomain is poorly known. A major structural break was suggested to complicate regional tectonic settings (Crawford, 1965). The Warooka Fault Zone, a major northwest–southeast basement fault zone across the Point Souttar area, is marked by total magnetic intensity (TMI) anomalies and extends southerly to Investigator Strait and northerly towards Eyre Peninsula. The fault zone is considered to be the tectono-boundary between the Cleve and Moonta Subdomains (Parker, 1993, fig.4.1). The middle Palaeoproterozoic Corny Point Paragneiss (2000–1845 Ma) on southern Yorke Peninsula is part of the Cleve Subdomain in the eastern Gawler Craton.

The Corny Point Paragneiss is a layered migmatite with a protolith of possible Hutchison Group equivalent and intruded by the Donington Granitoid Suite (~1855–1850 Ma; C.M. Fanning, ANU, pers. comm., 2000) on southern Yorke Peninsula. The migmatite was deformed by at least five tectonic phases during the Palaeoproterozoic – early Mesoproterozoic (Zang and Fanning, 2000). The Corny Point Paragneiss is the oldest unit known on Yorke Peninsula and U–Pb dating of metamorphic zircon has indicated a reliable age of the Kimban Deformation event 1 (KD_1).

Regional settings

Southern Yorke Peninsula is on the southeastern margin of the Gawler Craton. The craton has been divided into seven tectonic subdomains, including the Cleve and Moonta Subdomains in the southeast (Parker, 1993). The Cleve Subdomain contains high-grade metasediments of the Hutchison Group and magmatic rocks of the Lincoln Complex, including the Donington Granitoid Suite on eastern Eyre Peninsula and southern Yorke Peninsula. On northern Yorke Peninsula, the Moonta Subdomain is represented by lower grade metasediments and metavolcanics of the Wallaroo Group (1770–1730 Ma; Conor, 1995). The Warooka Fault Zone, at least 10 km wide in the Point Souttar, Point Turton and Warooka areas, separates the two subdomains (Figs 1, 2). To the southwest, the Donington Granitoid Suite and other Palaeoproterozoic gneisses, including the Corny Point Paragneiss, form the basement to the Wallaroo Group. The contact between the two units was recently intersected in drillhole TER 1.

The Cleve Subdomain consists of Archaean Sleaford Complex (>2440 Ma), Palaeoproterozoic Hutchison Group (2000–1859 Ma; Fanning, 1997) and Lincoln Complex (~1855–1700 Ma; Fanning, 1997) on Eyre Peninsula (Parker et al., 1988). The Hutchison Group unconformably overlies the Miltalie Gneiss (~2000 Ma) and contains metamorphic siliciclastics and carbonates. Sediments of the group were considered to have been deposited in a primeval rift basin (Parker and Lemon, 1982), then deformed and metamorphosed during the Kimban Orogeny. Syntectonic intrusives comprise the Lincoln Complex. The complex contains

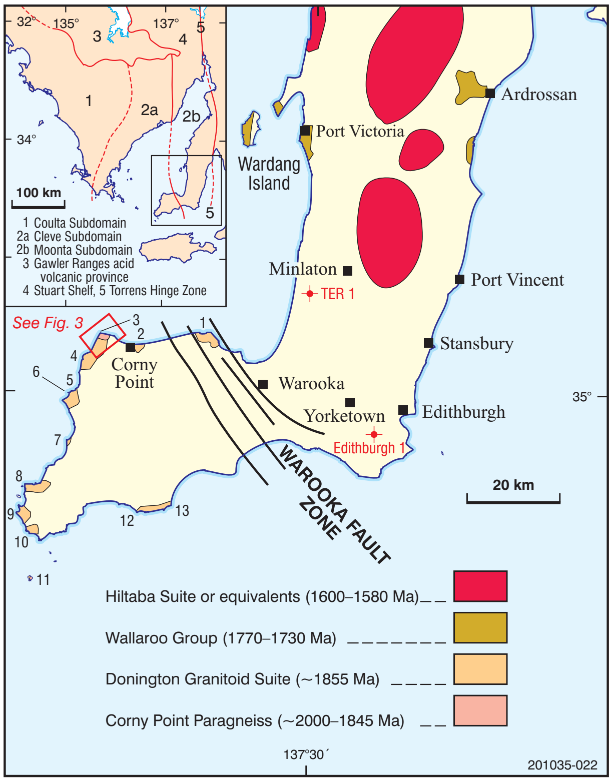


Fig. 1 Major tectonic elements in the southeastern Gawler Craton, and outcrops on Yorke Peninsula (after Parker, 1993). 1. Point Souttar; 2. Granite Hill; 3. Corny Point; 4. Point Deberg; 5. Swincers Rocks; 6. Gleesons Landing; 7. Point Margaret; 8. Royston Head; 9. Cape Spencer; 10. Stenhouse Bay; 11. Althorpe Island; 12. Butlers Beach; 13. Point Yorke.

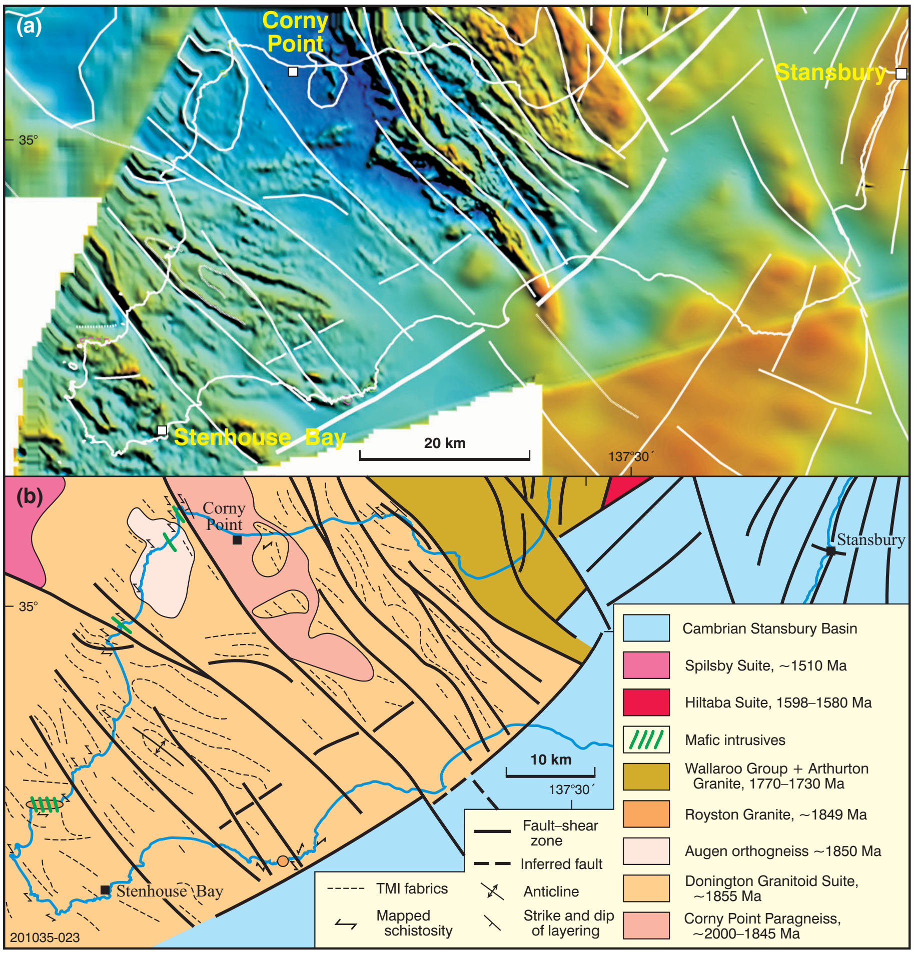


Fig. 2 ***(a)*** *TMI image of southern Yorke Peninsula,* ***(b)*** *solid geology interpretation.*

at least two felsic suites (Donington Granitoid and Moody Suites) on southern Eyre Peninsula. Basement rocks on southern Yorke Peninsula are considered to be Donington Granitoid Suite equivalent through similar petrological and U–Pb geochronological data. The suite occurs mainly to the east of the Kalinjala Mylonite Zone, where metasediments and paragneiss are exposed as pods or rafts.

Migmatitic Corny Point Paragneiss contains many boudins of metasediments and is considered to have a similar metamorphic history to the host Donington Granitoid Suite at Corny Point. The concordant fabrics (e.g. S_1) and banding suggest that both sedimentary protolith and magmatic granitoid were probably subjected to initial ductile deformation of the Kimban Orogeny. New growth of zircon in the migmatite (i.e. zircon rims) does reflect the approximate age of this event.

Lithology and distribution

Corny Point Paragneiss is named from a low cliff exposure at northern Corny Point (type locality, Fig. 3). It contains dark grey to white–grey, coarse-grained migmatite of quartz, plagioclase, biotite, alkali feldspar, garnet, fabrolithic sillimanite±orthopyroxene±clinopyroxene±cordierite±spinel±corundum etc. Fine-grained meta-argillite and calcsilicate lenses occur as xenoliths up to 2 m across and their elongation is largely parallel to layering. The sedimentary precursor is suggested to be Hutchison Group equivalent, which is widely distributed on Eyre Peninsula. Some fine-grained sandstone and calcsilicate xenoliths contain possible sedimentary layering or laminations (e.g. S_o), whereas at least four folding events have been interpreted by Richardson (1978) in the host migmatitic paragneiss. In the type section, the paragneiss is intruded by the Jussieu metadolerite (informal name) and Donington Granitoid Suite; the fabrics in all three units are concordant. Richardson (1978) considered that migmatisation of the paragneiss was prior to the deformation

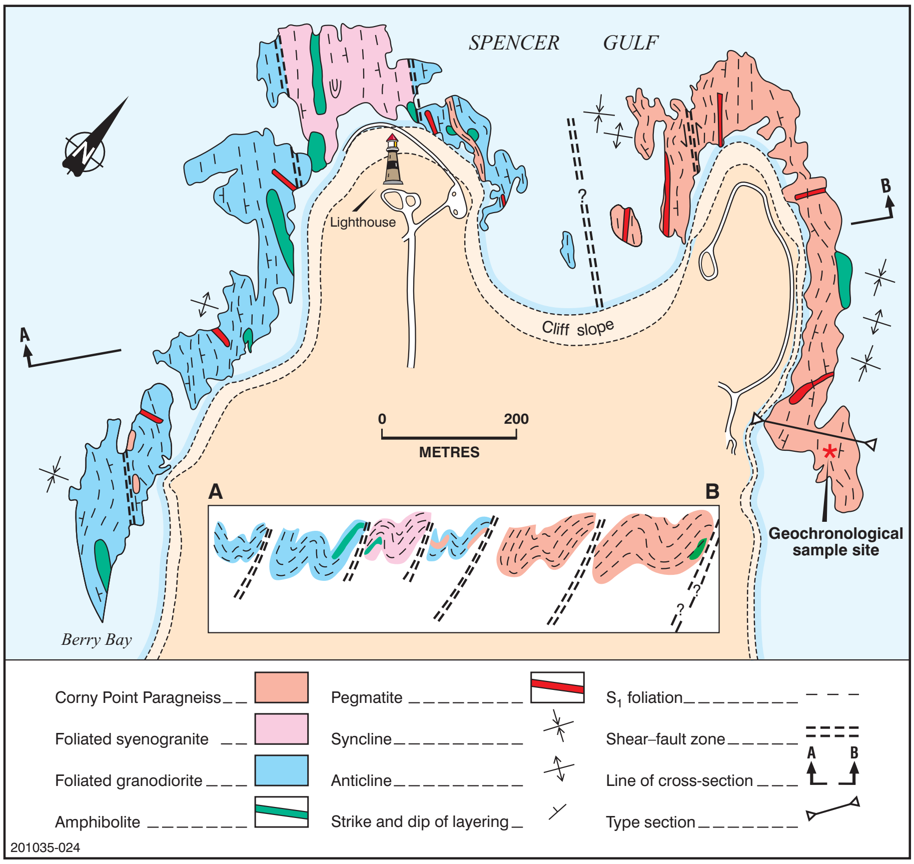


Fig. 3 Outcrops of the Corny Point Paragneiss and Donington Granitoid Suite in the Corny Point section (after Richardson, 1978).

Layered migmatite and calcsilicate lens with shearing tail; Corny Point Paragneiss. *(Photo 48192)*

Migmatitic layering of quartz–biotite–plagioclase–sillimanite–cordierite–pyroxene with garnet porphyroblasts; Corny Point Paragneiss. *(Photo 48193)*

and probably accompanied by mafic and felsic intrusions which have been dated in the range of ~1855–1850 Ma (C.M. Fanning, ANU, pers. comm., 2000).

The paragneiss displays a well-developed compositional layering which is parallel to S_1. The S_1 foliation is commonly defined by preferred orientation of sillimanite, biotite and elongated quartz–feldspar grains. Garnet is widespread and large porphyroblastic aggregates are common, particularly in migmatitic veins. Sillimanite is present in mafic-rich layers, and in late shear zones sillimanite is retrograded to muscovite (S_4). The paragneiss was intensely deformed with dominant S_1 fabrics, whereas the S_{2-4} fabrics are present only in shear zones or fold hinges (Richardson, 1978). Partial melting in the paragneiss and quartz–plagioclase–biotite–garnet–sillimanite mineral assemblages suggests at least upper amphibolite metamorphism. Locally layered migmatitic samples at Corny Point (R408913) contain a quartz–othoclase–garnet–biotite–sillimanite–plagioclase–cordierite±pyroxene assemblage, which was probably derived from a sandy pelite or an impure sandstone and is considered to have been metamorphosed to granulite facies (Purvis, 1999).

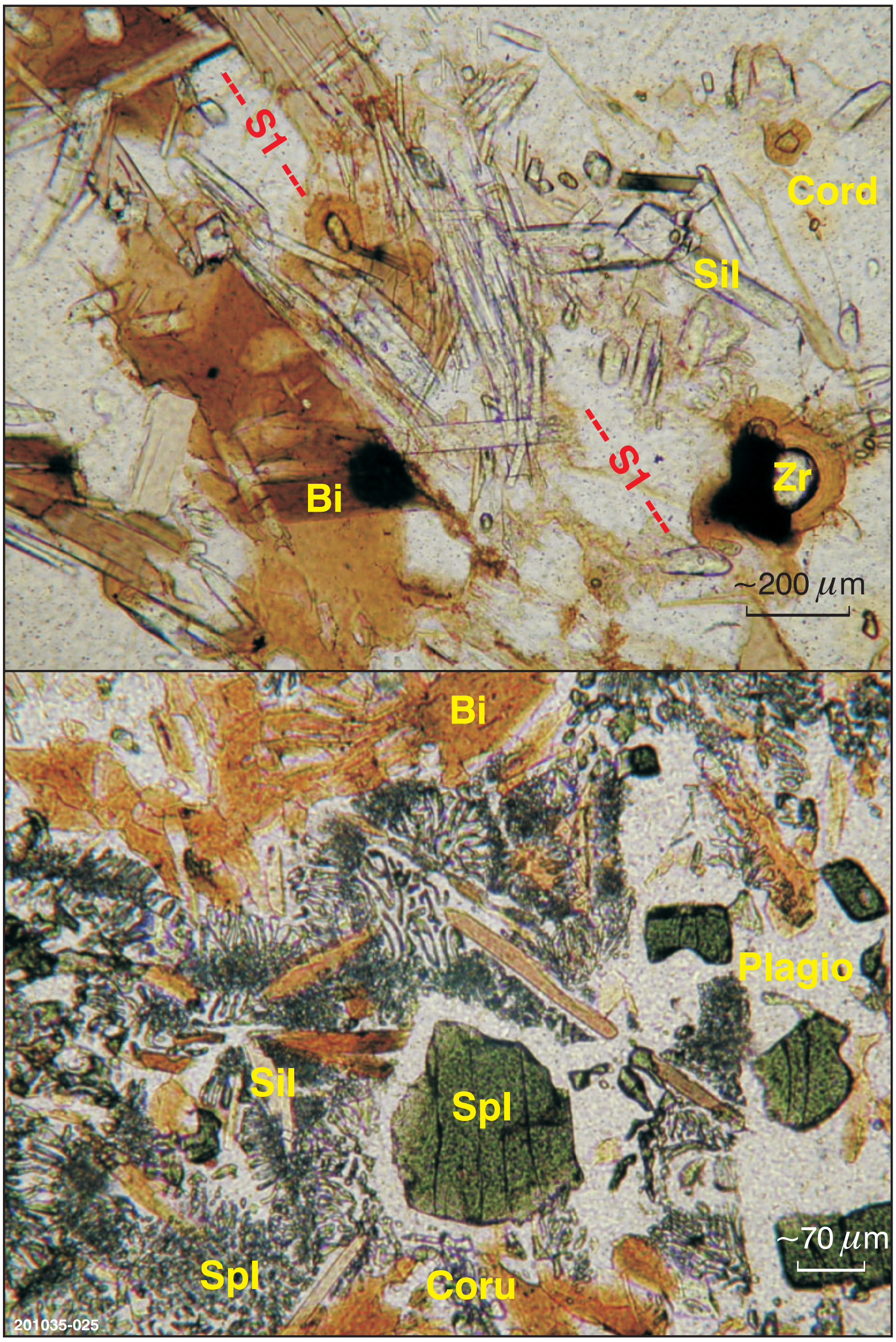
A migmatitic paragneiss band on northern Althorpe Island is hosted by biotite–hornblende adamellite. The paragneiss is layered with orthoclase–plagioclase-rich bands containing garnet–biotite–spinel–sillimanite–corundum assemblages (including vermiform spinel–feldspar intergrowths ±corundum), and plagioclase–orthopyroxene–quartz bands, all of which are possibly derived from a silica-deficient pelite (Purvis, 1999). The mineral assemblages suggest upper amphibolite to granulite-facies metamorphism.

A band of probable paragneiss is exposed at Point Souttar, which contains quartz–microcline–plagioclase–biotite–muscovite assemblage. The paragneiss is well foliated with the foliation defined by biotite–muscovite alignment. Quartz and feldspar grains are elongated along layering. Some round zircon grains are up to 0.15 mm. There is also rare limonite after pyrite. The paragneiss band is re-orientated parallel to the Warooka Fault Zone.

Migmatitic paragneiss xenoliths, up to 2 m wide and 10 m long, occur in augen orthogneiss at northern Point Deberg. The xenoliths are lens shaped, veined and boudinaged, and were stretched along the axis parallel to the regional foliation. The augen orthogneiss is dated at 1850±5 Ma (crystallisation age; C.M. Fanning, ANU, pers. comm., 2000), which suggests an approximate age for migmatisation of the paragneiss.

Geochemical data from both metasedimentary boudins and paragneiss show variable major element composition and silicification (>70% SiO_2) in the Corny Point area. Moderate CaO values in sediment samples and migmatite may suggest an overall calc-siliciclastic protolith.

The sedimentary setting for the protolith is poorly known. Metasedimentary boudins include both fine-grained sandstone and calcsilicate, but their original sedimentary features have been modified. The presence of



***Top:** Fibrolitic sillimanite, zircon and biotite enclosed in cordierite; Corny Point Paragneiss (thin section R408913). Pale yellow pleochroic haloes are visible in the cordierite crystal. Some zircon grains are aligned to the preferred foliation S_1.*

***Bottom:** Green spinel crystal, minor corundum and vermicular spinel–plagioclase intergrowths; Corny Point Paragneiss (thin section R408911). Brown biotite and colourless sillimanite flakes are randomly dispersed.*

spheroidal zircon and rounded quartz grains in relatively lightly deformed sedimentary boudins probably infer a continental source. Similarly, the boudins with interlayered sandy pelitic argillite and calcsilicate bands may suggest former mixed siliciclastics and carbonate deposits. It is possible that the protolith of the Corny Point Paragneiss was deposited on a continental shelf.

Geochronological analysis

Zircon was extracted from the migmatitic layer in the paragneiss for U–Pb dating. Generally, all zircon grains have a round core and newly grown rims; some align parallel to S_1. Twenty analyses were collected from 17 grains (Table 1), with an upper concordia intercept at 1845 +7.3/-6.6 Ma (Fig. 4a, c). Three ranges of values are present, peaking at ~2400, ~1920 and ~1845 Ma. The first two dates were derived from zircon cores, indicating the ages of provenance, and the third probably represents the metamorphic or migmatisation age of the paragneiss. The ~2400 Ma zircon is inherited from an Archaean protolith affected by the Sleafordian Orogeny (Daly and Fanning, 1993), whereas the younger ~1965–1915 Ma zircon group may indicate an inheritance from the Miltalie Gneiss or possibly reworked Hutchison Group rocks. The evidence of the zircon population suggests that the protolith of the Corny Point Paragneiss was most likely sourced from the Gawler Craton.

The majority of zircon grains have Th/U ratio values of <0.05, indicating a metamorphic origin. Eleven concordia values, with a 0.01–0.05 range in Th/U ratios, have an average of 1839.36 Ma ($^{207}Pb/^{206}Pb$), slightly younger than 1845 Ma, whereas grain number 9 records the youngest age of 1533±193 Ma, indicating possible zircon growth towards the early Mesoproterozoic.

The date, 1845 Ma is regarded as the metamorphic age of the Corny Point Paragneiss, inferred here as an equivalent to the peak metamorphism of the first phase of the Kimban Orogeny (KD_1), with an error ranging from 1852.3 to 1838.4 Ma.

Conclusion

The Corny Point Paragneiss is a layered migmatite with a protolith broadly equivalent in age to the middle Palaeoproterozoic Hutchison Group (2000–1859 Ma). This study indicates that the sedimentary protolith was probably sourced from the western to northwestern Gawler Craton and deposited on a continental shelf. Migmatitic paragneiss was metamorphosed up to granulite facies during the KD_1 event. The U–Pb ages on zircon suggest that the metamorphism of the KD_1 event on Yorke Peninsula peaked at ~1845 Ma.

Acknowledgement

The authors are grateful to Sue Daly, Michael Schwarz and Alan Purvis for valuable discussions. Sue Daly, Michael Schwarz and Gary Ferris critically read the manuscript.

Definition

Corny Point Paragneiss

Derivation of name: Corny Point township and coastal topographic feature, southwestern Yorke Peninsula, MAITLAND 1:250 000 map area.

Distribution: Outcrops at Corny Point, Althorpe Island, Point Souttar and Point Deberg. Possible distribution based on TMI interpretation is illustrated on Figure 2b.

Photomicrograph of zircon grains from the Corny Point Paragneiss (sample R392772); note that most grains have a rounded core. (Photo 48194)

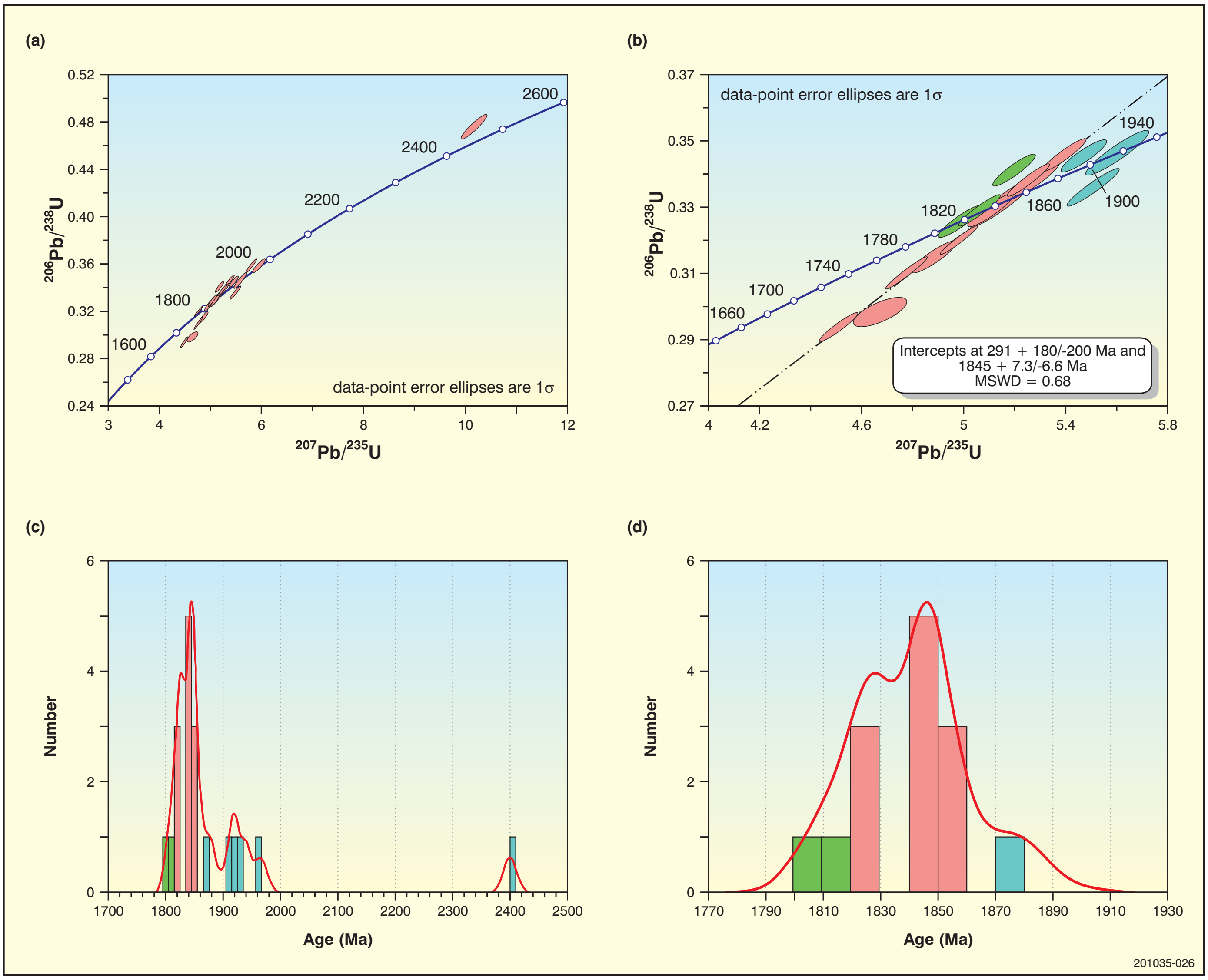


***Fig. 4** U–Pb zircon concordia diagrams for the Corny Point Paragneiss (sample R392772). **(a)** Concordia plot of multi-grain conventional zircon data, **(b)** close-up of concordant ages, **(c)** frequency diagram of zircon $^{207}Pb/^{206}Pb$ ages for all grains, **(d)** frequency of the concordant ages.*

Table 1 *Summary of SHRIMP U–Pb zircon results for sample R392772.*

Grain.spot	U (ppm)	Th/U	Pb (ppm)	Radiogenic ratios								
				$^{204}Pb/^{206}Pb$	$^{206}Pb/^{238}U$	±	$^{207}Pb/^{235}U$	±	$^{207}Pb/^{206}Pb$	±	$^{207}Pb/^{206}Pb$	±
1.1	1131	0.01	553	—	0.3150	0.0040	4.885	0.072	0.1125	0.0007	1840	11
1.2	535	0.42	311	0.000004	0.3359	0.0047	5.506	0.083	0.1189	0.0006	1940	8
2.1	342	0.13	198	0.000037	0.3587	0.0051	5.966	0.098	0.1206	0.0008	1965	13
4.1	1278	0.01	582	0.000005	0.2938	0.0037	4.512	0.061	0.1114	0.0005	1822	8
4.2	315	0.26	173	0.000046	0.3317	0.0063	5.155	0.107	0.1127	0.0007	1844	12
3.1	1353	0.01	650	0.000006	0.3101	0.0041	4.778	0.066	0.1117	0.0004	1828	6
5.1	1214	0.01	394	—	0.3386	0.0041	5.287	0.071	0.1133	0.0005	1852	8
6.1	1242	0.01	412	0.000006	0.3458	0.0041	5.393	0.070	0.1131	0.0005	1850	8
6.2	272	0.65	149	0.000067	0.4766	0.0087	10.178	0.209	0.1549	0.0011	2401	12
7.1	1545	0.01	475	0.000001	0.3200	0.0036	4.982	0.060	0.1129	0.0003	1847	5
8.1	1765	0.03	557	0.000007	0.3291	0.0039	5.062	0.066	0.1116	0.0005	1825	8
9.1	1179	0.06	82	0.013434	0.0671	0.0013	0.881	0.089	0.0953	0.0092	1533	193
10.1	1234	0.03	416	0.000131	0.3455	0.0040	5.470	0.073	0.1149	0.0007	1878	10
11.1	1431	0.08	447	0.000046	0.3257	0.0040	4.987	0.070	0.1111	0.0006	1817	10
12.1	1227	0.02	401	0.000226	0.3412	0.0039	5.198	0.068	0.1105	0.0006	1808	9
13.1	1595	0.02	505	0.000121	0.3291	0.0040	5.106	0.072	0.1125	0.0006	1841	10
14.1	1291	0.01	419	0.000021	0.3382	0.0040	5.253	0.067	0.1127	0.0004	1843	7
15.1	1027	0.14	368	0.000004	0.3590	0.0049	5.822	0.086	0.1176	0.0005	1920	8
16.1	353	0.29	311	0.000022	0.3463	0.0055	5.600	0.100	0.1173	0.0008	1915	12
17.1	1124	0.45	799	0.000058	0.2984	0.0036	4.674	0.085	0.1136	0.0014	1858	22

Type locality: Corny Point, 34°53’43”S, 137°00’44”E; the section is ~600 m long in the coastal exposure (Fig. 3).

Lithology: Layered, dark grey to light grey migmatitic paragneiss with a mineral assemblage of quartz–biotite–plagioclase–orthoclase–garnet–sillimanite–pyroxene±corundum±cordierite ±spinel. The protolith is suggested to be sandy siltstone and calcsilicate.

Relationships and boundary criteria: The paragneiss is intruded by both Donington Granitoid Suite (~1855–1850 Ma) and amphibolites of the Jussieu metadolerite and Tournefort Dyke Swarm at Corny Point. Isolated paragneiss pods or bands, hosted by the Donington Granitoid Suite, are present at Point Souttar, Point Deberg and Althorpe Island. The paragneiss is probably the oldest unit known on Yorke Peninsula.

Age and evidence: Metamorphic zircon grains have been extracted from a migmatite sample. Cores of zircon have been dated at ~2400 and ~1920 Ma respectively, suggesting that the sediment protolith had a probable Gawler Craton provenance. Newly grown zones give an upper concordia intercept of 1845+7.3/-6.6 Ma, indicating a probable peak metamorphism age of the KD_1 event.

Synonymy: Grey gneiss (Richardson, 1978). Not equivalent to the unpublished term ‘Corny Point augen gneiss’ of Webb (1978).

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