

208627: psammitic gneiss, Mount Malcolm

(Snowys Dam Formation, Arid Basin, Albany–Fraser Orogen)

Location and sampling

NORSEMAN (SI 51-2), FRASER RANGE (3433)
MGA Zone 51, 483453E 6433876N

Sampled on 22 May 2015

This sample was collected from an outcrop on a prominent hill on Southern Hills Station, about 3.9 km south of Southern Hills homestead, 3.2 km northwest of Salt Well, and 1.0 km west-southwest of Mount Malcolm.

Tectonic unit/rerelations

The unit sampled is a garnet-bearing psammitic gneiss of the 1332–1304 Ma Snowys Dam Formation of the 1600–1304 Ma Arid Basin (Spaggiari et al., 2014). The Snowys Dam Formation is a succession of pelitic, semipelitic to calcic, locally iron- and sulfide-rich metasedimentary rocks, interpreted to have been deposited in a foreland basin during the final stages of the development of the Arid Basin (Spaggiari et al., 2014). Intrusion of Fraser Zone gabbroic and granitic rocks within the Snowys Dam Formation was accompanied by high-grade metamorphism between c. 1305 and 1280 Ma (Spaggiari et al., 2014; Maier et al., 2016; Quentin de Gromard et al., 2017). At this locality, the gneissic rocks consist of interlayered semipelitic gneiss, garnet- and sillimanite-bearing pelitic gneiss, iron-rich metasedimentary gneiss, and minor amphibolite, all containing garnet-rich granitic leucosomes. Two samples of migmatitic gneiss from this locality yielded conservative maximum depositional ages of 1383 ± 4 and 1363 ± 9 Ma, and ages of 1304 ± 13 and 1298 ± 12 Ma for high-grade metamorphism (GSWA 194777, Kirkland et al., 2012; GSWA 194778, Kirkland et al., 2014). Monazite from an identical duplicate sample of psammitic gneiss from this locality yielded an age for high-grade metamorphism of 1302 ± 10 Ma (GSWA 208629, Fielding et al., 2019).

Petrographic description

The sample is a migmatitic psammitic gneiss (Fig. 1), consisting of about 40% quartz, 20% K-feldspar, 15% garnet, 10% sillimanite, 5% cordierite, 5% magnetite, 3% spinel, 1% biotite, and accessory monazite, zircon and apatite. The quartzofeldspathic matrix is fine grained, equigranular and interlobate. Quartz and K-feldspar grains show undulose extinction and subgrain development, indicating dynamic recrystallization via grain boundary migration at high temperature. Garnet porphyroblasts

are subhedral, about 0.5 mm across and occur in aggregates. Sillimanite orientation varies progressively from basal sections to elongate prisms across the thin section, suggesting the sample was folded after growth of sillimanite. Opaque minerals, possibly magnetite, and green spinel, possibly hercynite, occur in the matrix and as inclusions in garnet and sillimanite, where they appear to be in textural equilibrium. Cordierite is altered to pinnite and locally contains monazite inclusions. In the matrix, some magnetite exhibits a reaction rim of biotite plus prismatic cordierite. Monazite occurs in the matrix, as inclusions in cordierite, and rarely as inclusions in garnet.

Monazite characteristics

Monazites from this sample are colourless to pale yellow, anhedral to euhedral, and variably rounded. The crystals are mainly equant and up to 70 μm long. In high-contrast backscattered electron (BSE) images, some monazites exhibit complex, non-concentric internal structures. BSE images of representative monazites are shown in Figure 2. Rare earth element (REE) data were collected at the same time, and from the same volume, as the U–Pb data. The analysed monazites exhibit a negative Eu anomaly, with chondrite-normalized Eu/Eu^* ($\text{Eu}/[\text{Sm} \times \text{Gd}]$) of 0.15 – 0.35, and chondrite-normalized La/Sm of 3.3 – 3.9 and Gd/Yb of 816–2581 (Fig. 3). The consistency in these parameters indicates that the analysed monazites represent a sample from a single population that formed under similar conditions.

Analytical details

This sample was analysed in polished thin section on 25 September 2018, using the laser ablation split stream (LA-SS-ICP-MS) system (Lu et al., 2019). Nineteen analyses of the 44069 monazite standard obtained during the session indicated a weighted mean 207-corrected $^{238}\text{U}/^{206}\text{Pb}^*$ date of 426.0 ± 4.0 Ma (MSWD = 0.71), which agrees with the accepted value of 424.9 Ma. Nineteen analyses of secondary standard Stern 8153 obtained during the session yielded a weighted mean 207-corrected $^{238}\text{U}/^{206}\text{Pb}^*$ date of 511.2 ± 4.7 Ma (MSWD = 0.32), in agreement with the accepted value of 512 Ma. All propagated uncertainties are included in the errors of isotope ratios and dates listed in Table 1.

Results

Thirty-two analyses were obtained from 23 monazites. U–Pb results are listed in Table 1, and shown in a concordia diagram (Fig. 4).



Figure 1. Outcrop image for sample 208627: psammitic gneiss, Mount Malcolm

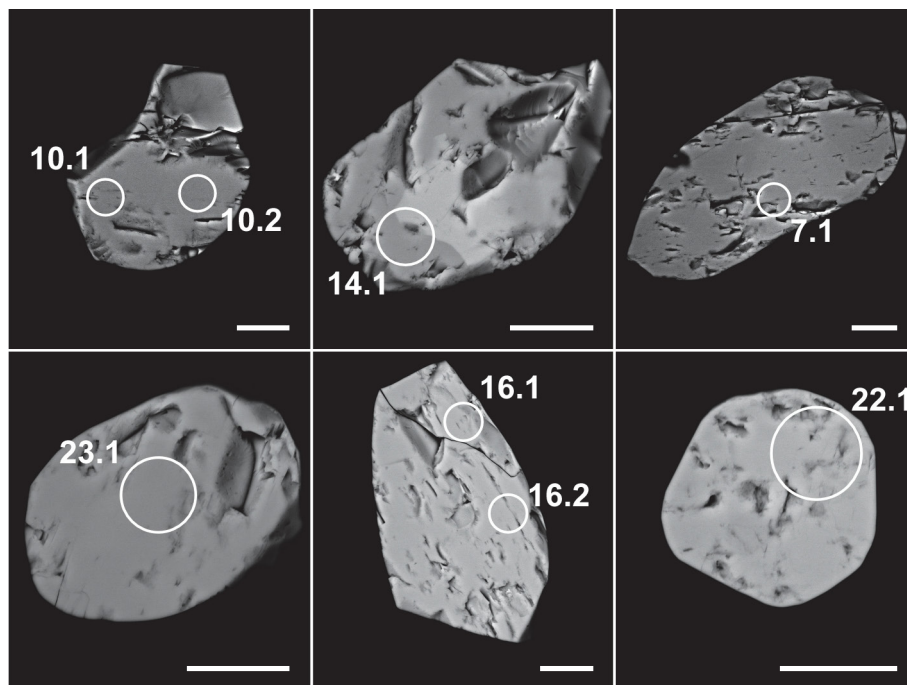


Figure 2. Backscattered electron (BSE) image of representative monazites from sample 208627: psammitic gneiss, Mount Malcolm. Numbered circles indicate the approximate locations of analysis sites; scale bars are 10 μm

Table 1. LA-SS-ICP-MS analytical results for monazites from sample 208627: psammitic gneiss, Mount Malcolm

Group ID	Spot no.	Grain. spot	^{238}U (ppm)	^{232}Th (ppm)	$\frac{^{232}\text{Th}}{^{238}\text{U}}$	$\frac{^{238}\text{U}}{^{206}\text{Pb}} \pm 1\sigma$	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}} \pm 1\sigma$	$\frac{^{238}\text{U}}{^{206}\text{Pb}}$ date (Ma) $\pm 1\sigma$	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$ date (Ma) $\pm 1\sigma$	Disc. (%)			
M	11	5.2	760	5940	7.8	4.715	0.098	0.08197	0.00135	1240	1245	32	0.4
M	12	6.1	579	11160	19.3	4.710	0.111	0.08140	0.00135	1241	1231	33	-0.8
M	7	3.1	629	7610	12.1	4.688	0.102	0.08130	0.00145	1246	1229	35	-1.4
M	21	9.1	174	16590	95.3	4.673	0.218	0.08160	0.00200	1250	1236	48	-1.1
M	24	10.2	626	3460	5.5	4.643	0.100	0.08380	0.00150	1258	1288	35	2.4
M	27	13.1	508	23300	45.9	4.613	0.106	0.08320	0.00150	1265	1274	35	0.7
M	10	5.1	705	6360	9.0	4.560	0.096	0.07978	0.00135	1278	1192	33	-7.3
M	18	8.2	1210	52600	43.5	4.554	0.092	0.08270	0.00140	1280	1262	33	-1.4
M	16	8.1	1320	54300	43.5	4.543	0.094	0.08327	0.00135	1282	1276	32	-0.5
M	32	16.2	351	8200	23.4	4.537	0.124	0.08560	0.00150	1284	1329	34	3.4
M	33	17.1	402	7250	18.0	4.535	0.101	0.08500	0.00160	1285	1316	37	2.4
M	45	22.1	364	56700	155.8	4.531	0.103	0.08530	0.00145	1286	1322	33	2.8
M	14	7.1	247	31300	126.7	4.500	0.122	0.08170	0.00165	1293	1238	40	-4.5
M	38	20.1	830	49700	59.9	4.488	0.131	0.08470	0.00140	1297	1309	32	0.9
M	2	1.2	785	11300	14.4	4.464	0.095	0.08190	0.00140	1303	1243	33	-4.8
M	1	1.1	381	9400	24.7	4.454	0.099	0.08170	0.00145	1306	1238	35	-5.4
M	23	10.1	594	3300	5.6	4.454	0.099	0.08250	0.00145	1306	1257	34	-3.8
M	4	2.2	424	4350	10.3	4.452	0.099	0.08290	0.00155	1306	1267	37	-3.1
M	3	2.1	566	6400	11.3	4.446	0.098	0.08250	0.00140	1308	1257	33	-4.0
M	34	18.1	530	8200	15.5	4.437	0.108	0.08360	0.00145	1310	1283	34	-2.1
M	30	15.1	345	13000	37.7	4.423	0.108	0.08580	0.00160	1314	1334	36	1.5
M	36	19.1	1160	67300	58.0	4.421	0.097	0.08412	0.00140	1315	1295	32	-1.5
M	46	23.1	504	81500	161.7	4.419	0.098	0.08550	0.00150	1315	1327	34	0.9
M	26	12.1	478	16200	33.9	4.413	0.107	0.08280	0.00145	1317	1265	34	-4.1
M	25	11.1	366	4590	12.5	4.409	0.107	0.08290	0.00155	1318	1267	37	-4.0
M	9	4.1	699	5690	8.1	4.398	0.092	0.08252	0.00135	1321	1258	32	-5.0
M	28	13.2	480	20900	43.5	4.378	0.096	0.08380	0.00145	1326	1288	34	-3.0
M	31	16.1	296	6670	22.5	4.374	0.115	0.08700	0.00175	1327	1360	39	2.5
M	29	14.1	301	44000	146.2	4.365	0.114	0.08380	0.00155	1330	1288	36	-3.3
M	41	21.1	554	38500	69.5	4.359	0.105	0.08573	0.00140	1331	1332	32	0.1
M	42	21.2	303	39200	129.4	4.333	0.113	0.08300	0.00155	1339	1269	36	-5.5
M	22	9.2	239	19700	82.4	4.274	0.110	0.08450	0.00160	1355	1304	37	-3.9

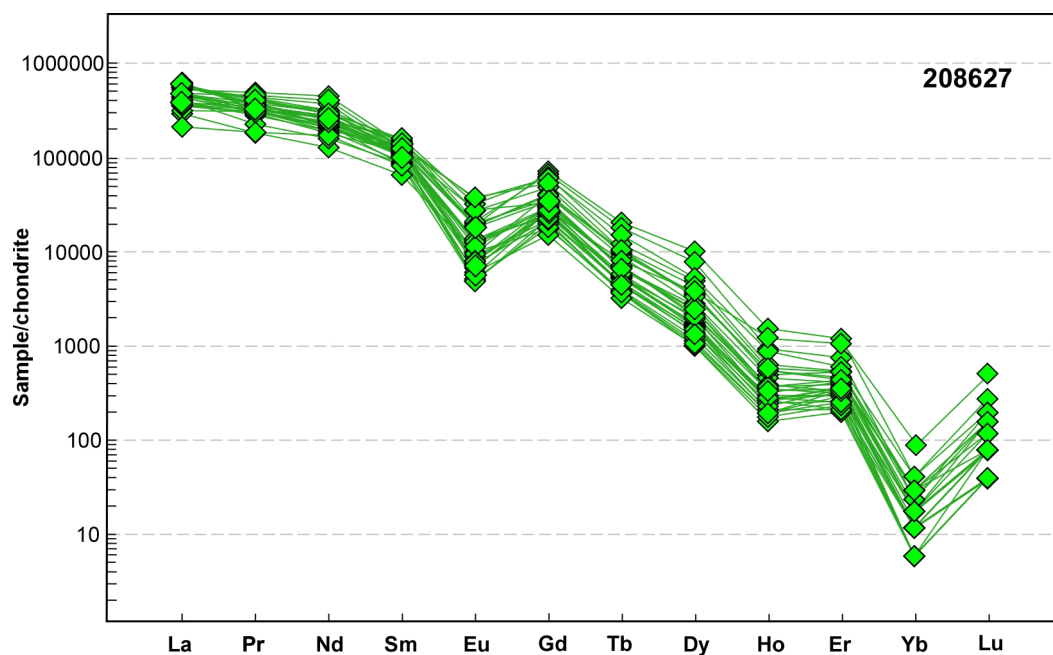


Figure 3. Chondrite-normalized REE data for monazites from sample 208627: psammitic gneiss, Mount Malcolm. Green diamonds indicate Group M (metamorphic monazites). Normalization values are from Sun and McDonough (1989)

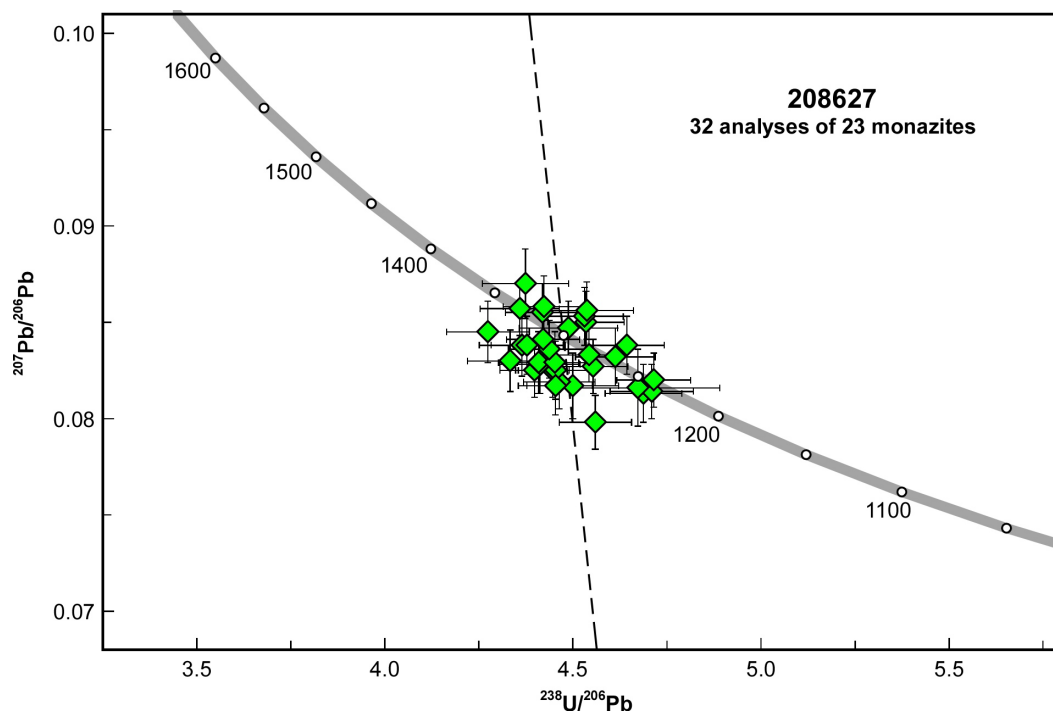


Figure 4. U-Pb analytical data, not corrected for common Pb, for monazites from sample 208627: psammitic gneiss, Mount Malcolm. Green diamonds indicate Group M (metamorphic monazites). The dashed line indicates a regression from initial Pb through data in Group M

Interpretation

The analyses are concordant to slightly discordant (Fig. 4). The date for this sample is determined from the intersection with the concordia curve of a regression through uncorrected data, anchored at contemporaneous initial Pb ($^{207}\text{Pb}/^{206}\text{Pb} = 0.9345$ at 1299 Ma; Stacey and Kramers, 1975). The analyses form a single group, based on their $^{207}\text{Pb}/^{206}\text{Pb}$ and $^{238}\text{U}/^{206}\text{Pb}$ ratios.

Group M comprises 32 analyses of 23 monazites (Table 1), which yield a regression that intersects the concordia curve at 1299 ± 11 Ma (MSWD = 1.0).

The date of 1299 ± 11 Ma for the 32 analyses in Group M is interpreted as the age of high-grade metamorphism.

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Recommended reference for this publication

Fielding, IOH, Wingate, MTD, Lu, Y and Quentin de Gromard, R 2019, 208627: psammitic gneiss, Fraser Range; Geochronology Record 1615: Geological Survey of Western Australia, 5p.

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