

**Table S1.** Basic description of studied zircon samples.

Sample No.	Localization	Rock Description	Shape of the Zircon Grains, Inclusions	Associated Minerals
PHR-174	Madeira pluton, outcrop	Albite granite, border facies, medium grained, dark brown-red colored	euhedral crystals, inclusions of quartz,	Albite, quartz, K-feldspar, Li-mica, Fe-oxide, fluorite, cassiterite, columbite, thorite, galena, pyrite, Ce-fluoride
PHR-127	Madeira pluton, outcrop	Albite granite, core facies, fluidal, medium grained, light gray in color	subhedral grains, inclusions in galena	Albite, K-feldspar, quartz, Li-mica, cryolite, aegirine, galena, sphalerite, pyrochlore, fluorite, xenotime, thorite, native Bi
PHR-163	Madeira pluton, borehole 00/400W, depth 99.1 m	Albite granite, core facies, medium grained, gray	euhedral to subhedral grains, vacuolized cores, Hf-enriched rims,	Albite, quartz, K-feldspar, cryolite, Li-mica, aegirine, Fe-oxide, microlite, cassiterite, columbite, pyrochlore, thorite
4894	Madeira pluton, outcrop	Albite granite, core facies, medium grained, dark gray, cryolite-rich	euhedral to subhedral crystals, Hf-rich rims, inclusions of thorite and cryolite,	K-feldspar, quartz, albite, cryolite, Li-mica, aegirine, Fe-oxide, microlite, columbite, thorite
Iv-34	Ivigtut, outcrop in the old open pit mine	quartz- and sulphide-enriched pods in the cryolite body	subhedral to anhedral grains in carbonate	siderite, calcite, quartz, columbite, sulfides and Sr,Th-phases
Iv-56a	Ivigtut, outcrop in the old open pit mine	greisenized granite near contact with pegmatite	subhedral grains with inclusions of Sr,Th-carbonate	quartz, K-feldspar, Fe-oxides, cryolite, Sr,Th-carbonate, cassiterite, columbite, fluorite, chalcopryrite, galena, clay
Iv-92	Ivigtut, debris near the old mine	quartz-feldspar layered dike with oriented texture	mm-sized zircon crystals growing perpendicularly to surface of K-feldspar layers	quartz, K-feldspar, cryolite, xenotime, galena
Iv-X-3	Ivigtut, outcrop in the old open pit mine	fluorite-chalcedony metasomatite in granite	euhedral to subhedral crystals in quartz	quartz, chalcedony, fluorite, columbite, pyrite, xenotime, thorite
KB-2	Khan Bogd, western body	coarse-grained peralkaline amphibole granite	rounded admixtures in hematitized magnetite	quartz, K-feldspar, plagioclase, hematite, Mn-carbonate, Na-amphibole, ilmenite, monazite
KB-3	Khan Bogd, western body	porphyritic coarse-grained peralkaline amphibole granite near western contact	small rounded grains and botryoidal	quartz, K-feldspar, plagioclase, Na-amphibole, chlorite, remnants of altered Zr-silicates, apatite

KB-4	Khan Bogd, western body	porphyritic coarse-grained peralkaline amphibole granite near western contact, strongly metasomatized	anhedral grains and botryoidal aggregates, rounded admixtures in hematitized magnetite	quartz, K-feldspar, plagioclase, Na-amphibole, magnetite, altered Zr-silikates, monazite, bastnasite
KB-6	Khan Bogd, roof zone of the western body	pealkaline aplite/ pegmatite	late veinlets of zircon-xenotime solid solutions in relicts of primary Zr-silikates	quartz, plagioclase, Na-amphibole, relicts of Na,Ca-zirconosilicate, calciocatapleite, calcite, bastnasite, xenotime
KB-13	Khan Bogd, roof zone of the western body	peralkaline granite porphyry	rounded sun-like shaped aggregates in association with Na-pyroxene	quartz, alkalifeldspar, Na-pyroxene, titanite, monazite, bastnasite
EDG09	Khan Bogd, roof zone of the western body	dike of porphyritic peralkaline Px-granite	rounded grains with Hf-enriched rims	quartz, perthite, Na-pyroxene, rutile, bastnasite, Fe-oxide
KhaBur2	Khalzan Buregte, outcrop, older suite, phase 2	medium-grained peralkaline pyroxene syenite	radial zircon aggregates, Zr, SiP,As,LREE transitional phases in association with	plagioclase, K-feldspar, Na-pyroxene, relicts of NaZr- and BaZr-silikates, xenotime, chernovite
KhaBur3	Khalzan Buregte, outcoop, older suite, phase 2	coarse-grained peralkaline quartz-rich pyroxene granite	botryoidal aggregates	quartz, plagioclase, K-feldspar, Na-pyroxene, chalcoppyrite, Pb-teluride
KhaBur4	Khalzan Buregte, outcrop, older suite, phase 2	coarse-grained peralkaline quartz-rich pyroxene granite	anhedral grains in relicts of primary Zr,Na-silicate	quartz, plagioclase, K-feldspar, Na-pyroxene, 3-5mm sized relicts of Zr.-silicates, clay minerals, YCa-silicate
KhaBur6	Khalzan Buregte, outcrop, older suite, phase 3	fine-grained layered pyroxene-rich peralkaline syenite	altered subhedral grains, botryoidal aggregates	plagioclase, K-feldspar, quartz, Na-pyroxene, titanite, rutile,
KhaBur7	Khalzan Buregte, outcrop, older suite, phase 3	fine-grained layered amphibole-rich peralkaline syenite	small anhedral grains in amphibole matrix among albite crystals	plagioclase, Na-amphibole, K-feldspar, monazite
KhaBur8	Khalzan Buregte, outcrop, older suite, phase 3	amphibole-rich peralkaline syenite	small grains in Qtz-Ab matrix among Na-pyroxene crystals, scarce larger subhedral crystals	K-feldspar, plagioclase, quartz, amphibole, biotite, apatite, monazite, xenotime,
KhaBur14	Khalzan Buregte, outcrop, older suite, phase 4	red medium-grained quartz peralkaline amphibole	anhedral grains associated with Fe-oxides and REE-carbonates	K-feldspar, plagioclase, amphibole, quartz, calcite, REE-carbonates, Fe-oxide
KhaBur13	Khalzan Buregte, outcrop, older suite, phase 5	dark fine-grained apmhibole-rich peralkaline syenite	secondary anhedral zircon associated with As,P,REE-phases in relicts of primary Zr-silicate	K-feldspar, albite, Na-pyroxene, quartz, monazite, chernovite, relicts of zirconosilikates (?) transformed to clay and Al,Ca-rich zircon
KhaBur9	Khalzan Buregte, outcrop, older suite,	layered pealkaline granite with red K-feldspar	subhedral grains associated with thorite	quartz, K-feldspar, albite, rare Fe-mica, cassiterite,

	phase 7		and Fe-oxides	thorite, rutile, columbite, fluorite,
KhaBur10	Khalzan Buregte, outcrop, younger suite, phase 7	amazonite pegmatite	euhedral crystals with Hf-rich rims associated with thorite	quartz, perthitic alkalifeldspar, albite, rare Fe-mica, columbite, thorite
KhaBur11	Khalzan Buregte, outcrop, younger suite, phase 7	medium-grained peralkaline amazonite granite with rounded quartz and miarolytic cavities	subhedral crystals with vacuolized cores	quartz, perthitic alkalifeldspar, albite, rare Fe-mica, fluorite, microlite

Table S2. Important geochemical values.

Reservoir	Chondrite C1	Primitive Mantle	Silicate Earth	Bulk Continental Crust	Lower Continental Crust	Middle Continental Crust	Upper Continental Crust
Author	McDonough	Lyuyetskaya	McDonough	Rudnick+Gao	Rudnick+Gao	Rudnick+Gao	Rudnick+Gao
Zr (ppm)	3.82	8.42	10.5	132	68	149	193
Hf (ppm)	0.103	0.227	0.283	3.7	1.9	4.4	5.3
Nb (ppm)	0.24	0.46	0.658	8	5	10	12
Ta (ppm)	0.014	0.03	0.037	0.7	0.6	0.6	0.9
Y (ppm)	1.57	3.37	4.3	19	16	20	21
Yb (ppm)	0.161	0.346	0.441	1.9	1.5	2.2	2
Zr/Hf (ppm/ppm)	37.1	37.1	37.1	35.7	35.8	33.9	36.4
Nb/Ta (ppm/ppm)	17.1	15.3	17.8	11.4	8.3	16.7	13.3
Y/Yb (ppm/ppm)	9.8	9.7	9.8	10.0	10.7	9.1	10.5
ZrO <sub>2</sub> /HfO <sub>2</sub> (by weight)	42.5	42.5	42.5	40.9	41.0	38.8	41.7
Nb <sub>2</sub> O <sub>5</sub> /Ta <sub>2</sub> O <sub>5</sub> (by weight)	20.1	18.0	20.8	13.4	9.8	19.5	15.6
Y <sub>2</sub> O <sub>3</sub> /Yb <sub>2</sub> O <sub>3</sub> (by weight)	10.9	10.9	10.9	11.2	11.9	10.1	11.7
Zr/Hf atomic	72.6	72.6	72.6	69.8	70.0	66.3	71.3
Nb/Ta atomic	33.4	29.9	34.6	22.3	16.2	32.5	26.0
Y/Yb atomic	19.0	19.0	19.0	19.5	20.8	17.7	20.4