

U-Pb AGES FOR INTRUSIVE ROCKS AT THE HUCKLEBERRY PORPHYRY COPPER DEPOSIT, TAHTSA LAKE DISTRICT, WHITESAIL LAKE MAP AREA, WEST-CENTRAL BRITISH COLUMBIA (93E/11)

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INTRODUCTION

The Huckleberry porphyry copper deposit is located about 85 km southwest of Houston, in the Tahtsa Lake district of west-central British Columbia (Whitesail Lake map area; 93E) (Figure 1). Previous workers have associated mineralization at the Huckleberry deposit with the intrusion of two small porphyry stocks into Hazelton Group country rocks (Carter, 1974; James, 1976; Jackson and Illerbrun, 1995). In this report we present new U-Pb data and interpreted ages for samples from these intrusions.

This work is one component of a regional U-Pb dating study of mineral deposits in central British Columbia. A more focused mapping, metallogeny and

geochronology study continues at the Huckleberry deposit and in the Whiting Creek area to the north (Figure 2). Both of these investigations are being conducted under the auspices of the Magmatic-Hydrothermal Project of the Mineral Deposit Research Unit. The U-Pb ages reported herein were determined at the Geochronology Laboratory of the Department of Earth and Ocean Sciences at the University of British Columbia.

PREVIOUS WORK

The first regional bedrock mapping of the Whitesail Lake map area was conducted in the 1930's (Hedley, 1935). Mapping continued during the 1940's and 1950's, culminating in the publication of a four mile map sheet and an accompanying report by the Geological Survey of Canada (Duffell, 1959).

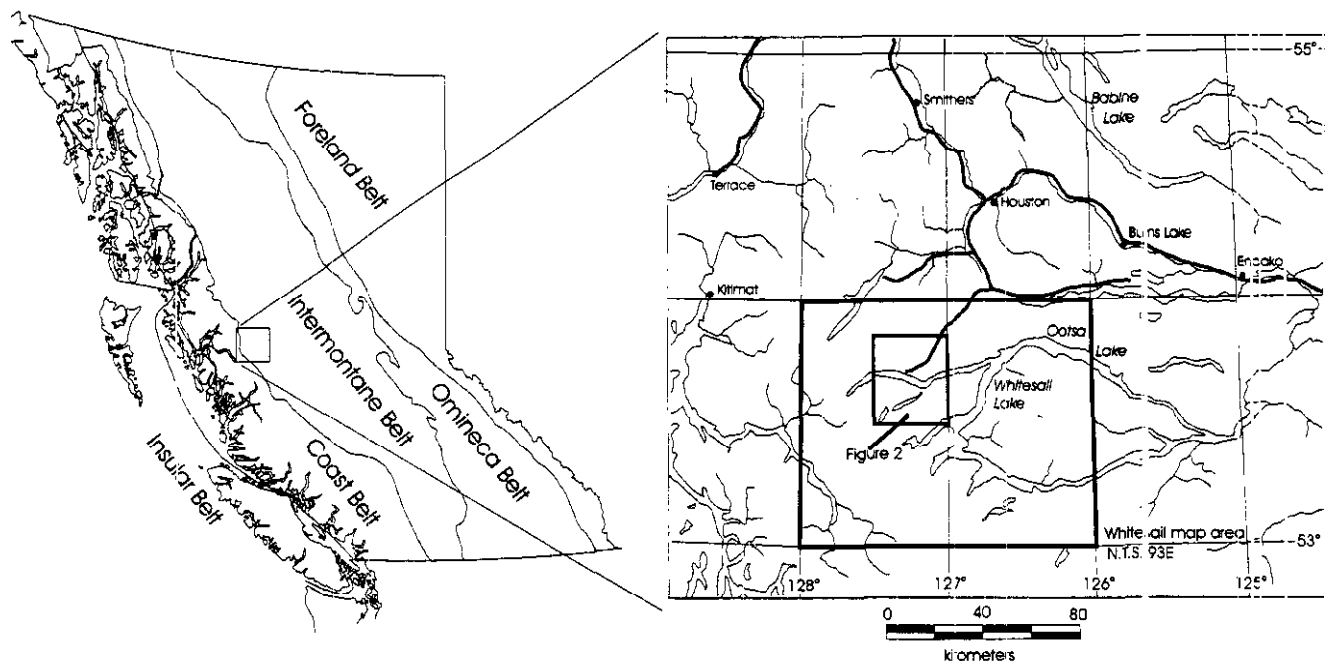


Figure 1. Location map of west-central British Columbia showing the Whitesail Lake map area (NTS 93E) and the area of Figure 2. Inset shows regional position of the Tahtsa Lake area in west-central British Columbia.

A regional stream sediment geochemical survey carried out within the Tahtsa Lake area during the early 1960's by Kennco Explorations (Western) Limited led to the discovery of the Berg and Huckleberry (Main zone) porphyry copper occurrences. These discoveries were responsible for an escalating level of mineral exploration in the area during the 1960's and 1970's, which led to the identification of additional porphyry copper occurrences in the area. Studies focusing on the geology of individual deposits and the district as a whole were conducted by the British Columbia Ministry of Energy, Mines and Petroleum Resources (Sutherland-Brown, 1966, 1969; Carter, 1970, 1974; Church, 1971; Carter, 1981; MacIntyre, 1985) and as thesis work (Cawthorn, 1973; MacIntyre, 1974, 1976; Richards, 1974; Panteleyev, 1976). The results of several studies in the area were published in a 1976 volume on porphyry deposits of the Canadian Cordillera (Christopher and Carter, 1976; Carter, 1976; James, 1976). More recent regional mapping in the Whitesail Lake map area was carried out by Woodsworth, (1980) of the Geological Survey of Canada and Diakow and Mihalynuk (1987a,b) of the British Columbia Geological Survey. An up-to-date review of the Huckleberry deposit (Jackson and Illerbrun, 1995) was published in a second volume on porphyry deposits of the Canadian Cordillera.

Detailed geological and geophysical work on the Huckleberry property, conducted by Kennco Explorations, began soon after the initial discovery in 1962 and continued until 1971, when the property was optioned to Granby Mining Company Limited. During the following two years a detailed drilling programme focused on Main zone mineralization, after which activity on the property ceased until 1989. At this time Noranda Exploration Company Limited began work on the east side of the property but subsequently dropped its option. Kennecott Canada optioned the property to New Canamin Resources Limited in 1992. In 1993, during geotechnical drilling by New Canamin Resources for a future tailings pond, the East zone of mineralization was discovered. Drilling programmes carried out by New Canamin Resources during the remainder of the early 1990's focused on the determination of ore reserves in the Main and East mineralized zones. In July of 1995 Princeton Mining Corporation purchased New Canamin Resources. Princeton Mining Corporation currently controls 60 percent of the operating company, Huckleberry Mines, Limited.

GEOLOGY

REGIONAL GEOLOGY

The Tahtsa Lake district lies near the western margin of the Intermontane Belt and within the Stikine accreted terrane (Figure 1). The area is underlain by several unconformity bound volcanic and/or siliciclastic assemblages. In ascending order these are: Lower to Middle Jurassic arc volcanic and clastic sedimentary strata of the Hazelton Group; wackes, fine grained sedimentary rocks and tuffs of the Middle Jurassic Ashman Formation, part of the Bowser Lake Group; Lower Cretaceous, mainly Albian turbiditic sedimentary rocks and subordinate basalt flows of the Skeena Group; and, volcanic and subordinate sedimentary rocks of the Upper Cretaceous Kasalka Group (Figure 2).

These Jurassic and Cretaceous strata in the area have been intruded by numerous small and medium-sized, high-level stocks of the Early to Late Cretaceous Kasalka intrusions, Late Cretaceous Bulkley intrusions, and the Eocene Nanika intrusions (MacIntyre, 1985).

Kasalka intrusions are a group of small intrusive bodies which are commonly areally associated with, and compositionally/texturally similar to Kasalka Group volcanic rocks (MacIntyre, 1985). Fine grained, porphyritic augite-hornblende bearing diorities comprise the majority of these intrusives.

The Bulkley intrusions are defined as mainly small to medium-sized (usually 1-5 km in diameter), high-level, compositionally intermediate, hornblende and/or biotite bearing bodies of Late Cretaceous age, which intrude Lower Jurassic to Lower Cretaceous strata (Carter, 1974, 1976, 1981). They are areally, and likely genetically related to the Huckleberry and other important porphyry copper deposits in the Tahtsa Lake district (Carter, 1974; Christopher and Carter, 1976; James, 1976).

The Bulkley intrusions have been separated into three subtypes by MacIntyre (1985). These are small porphyritic stocks, such as the Main Zone stock at the Huckleberry deposit; relatively large, compositionally zoned, equigranular intrusions, such as the Whiting or Sibola stocks; and late, porphyritic quartz monzonite dyke swarms that cut both of the former types.

Bulkley intrusions are commonly located along, or adjacent to steep north to northwest-trending faults, suggesting that their final emplacement was structurally controlled (Carter, 1976). Local doming of country rock adjacent to some intrusions is indicative of forceful intrusion mechanisms. Contact aureoles generally extend outwards approximately 400-1000 metres from the margins of intrusions.

The Nanika intrusions refer to high-level, compositionally intermediate stocks of Eocene age. They are distinguished from Late Cretaceous intrusions by their greater proportion of primary K-Feldspar. The Berg stock, which is associated with the Berg porphyry copper deposit, is a typical Nanika intrusion.

Rocks of the Taitsa Lake district have undergone varying degrees of folding and faulting. Hazelton and Skeena Group strata have undergone open to tight folding while Late Cretaceous and younger rocks are only gently warped. Pre-Tertiary rocks are cut by steep, generally north to northwest trending faults.

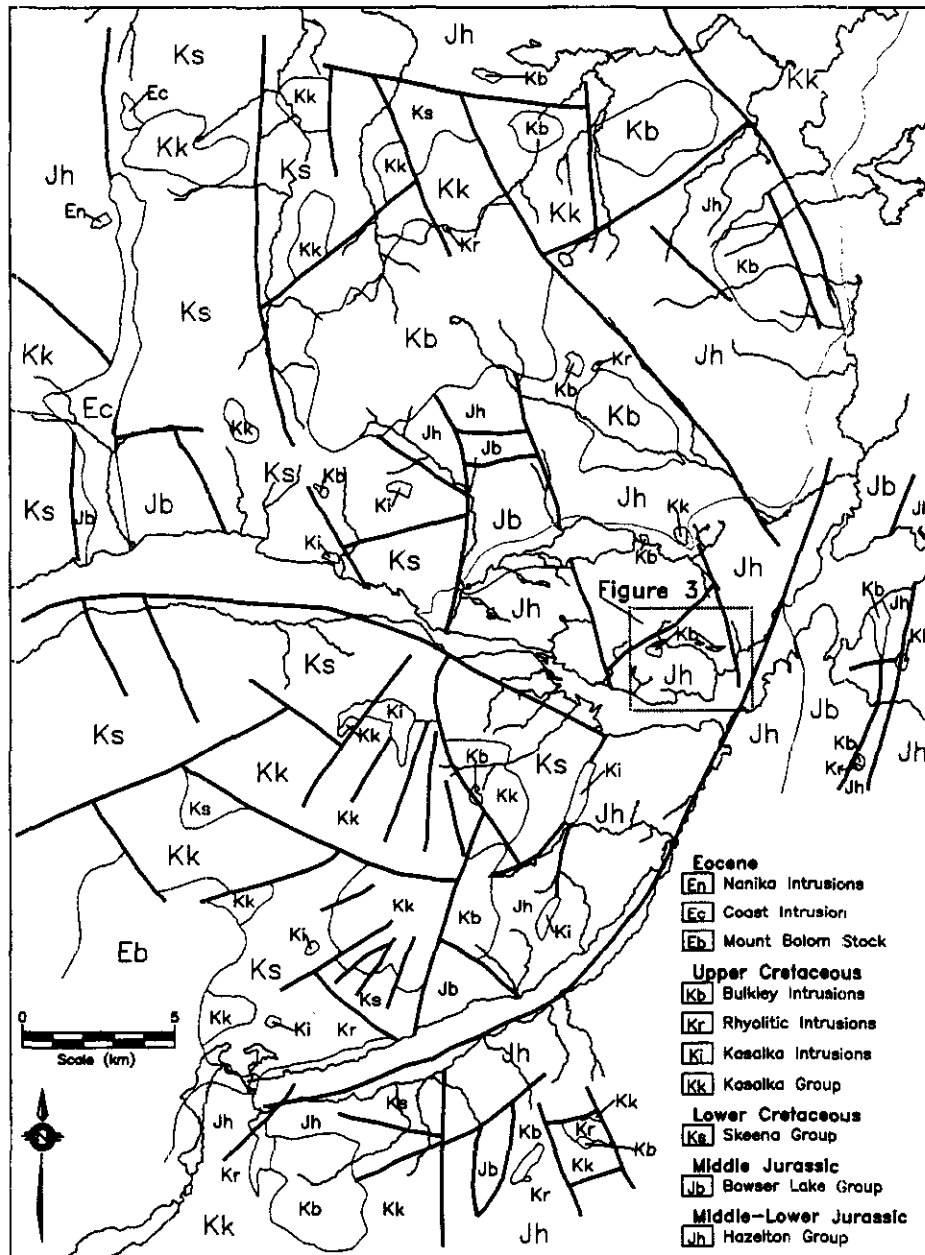


Figure 2. Regional geological map of the Taitsa Lake District, after MacIntyre (1985).

GEOLOGY AND MINERALIZATION OF THE HUCKLEBERRY DEPOSIT

The Huckleberry deposit is underlain by andesites, dacites and tuffs of the Telkwa Formation of the Hazelton Group. These rocks were intruded by at least two small granodiorite porphyry stocks (the porphyries dated in this study), which metamorphosed adjacent country rock and generated a composite alteration halo of approximately 4 x 2 kilometres in dimension. Two ore zones have been recognized at the Huckleberry deposit (Figure 3). The close spatial relationship of these zones to the Main Zone and East Zone stocks and associated alteration halo/contact aureole led previous workers to propose a model in which mineralization was genetically related to these intrusions (Carter, 1974; James, 1976; Jackson and Illerbrun, 1995). A late Cretaceous age was assigned to the Main Zone stock based on a K-Ar biotite age of 83.1 ± 3.0 Ma (Carter, 1976).

The Main Zone and East Zone stocks are biotite \pm hornblende granodiorite porphyries. Recent studies suggest that they both comprise the older phase of a composite body which consists of two phases of granodiorite. Contact relationships between these two phases suggests that they are broadly contemporaneous. Phenocryst phases commonly found in the Main Zone and East Zone stocks are plagioclase, biotite and/or hornblende and minor quartz. These phases are set in a fine to medium-grained matrix of quartz and plagioclase (Carter, 1974, 1976; MacIntyre, 1985; Jackson and Illerbrun, 1995). Important accessory phases are magnetite, apatite and zircon. Alteration K-feldspar makes up a small proportion of the matrix and some plagioclase grains have been partly replaced by fine-grained sericite.

Late (post-mineral) lamprophyre and microdiorite dykes cut mineralized zones on the property. One of the latter was sampled for U-Pb dating in this study but no zircon was recovered.

The Main and East mineralized zones are spatially associated with the Main Zone and East Zone stocks, respectively (Figure 3). The Main zone, to the west, lies adjacent to, and follows the margin of the Main Zone stock, and is hosted completely in hornfelsed Hazelton Group volcanic rocks. The East zone is hosted by the East Zone stock and adjacent volcanic rocks. Both ore zones occur within potassic alteration zones, and in both, mineralization occurs primarily within a stockwork of veinlets and fractures which contain or are coated with chalcopyrite, pyrite and subordinate molybdenite and traces of bornite. The intensity of alteration increases towards the stocks and ore zones from chloritic to pyritic to potassic (Jackson and Illerbrun, 1995).

Ore reserves at the Huckleberry deposit have been estimated at 53.7 million tonnes grading 0.445% Cu, 0.013% Mo and 0.06 g/t Au, based on a 0.30% Cu cutoff, for the Main zone, and 108.4 million tonnes grading 0.484% Cu, 0.014% Mo and 0.055 g/t Au at a cut off grade of 0.30% Cu, for the East zone (Jackson and Illerbrun, 1995).

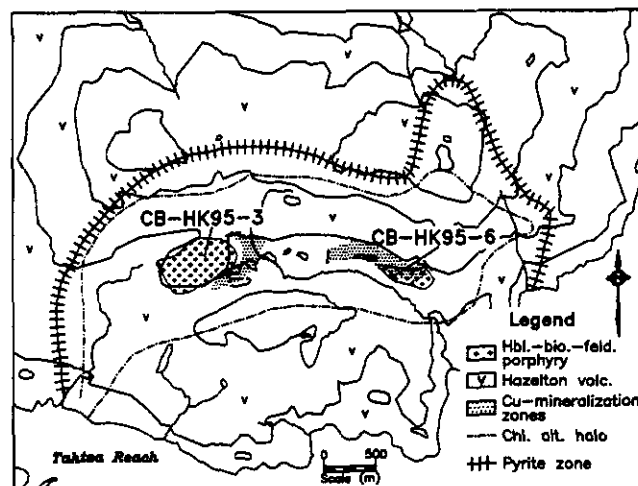


Figure 3. Map of the Huckleberry deposit, after Jackson and Illerbrun (1995).

U-Pb GEOCHRONOLOGY

Three rock samples from the Huckleberry property were collected for U-Pb geochronology during the 1995 field season (Figure 3). These include the Main Zone and East Zone stocks, which intrude hornfels and are thought to be responsible for mineralization on the property (Carter, 1974; James, 1976; Jackson and Illerbrun, 1995), and a post-mineral cross cutting microdiorite dyke. The Main Zone and East Zone stocks yielded abundant high quality, pale pink, prismatic zircon, whereas no zircon or other minerals that can be used for U-Pb dating were recovered from the dyke.

In the paragraphs below descriptions of the two dated samples are given. This is followed by descriptions of zircon recovered from each sample and the presentation, discussion and interpretation of U-Pb data for each. These data are plotted on concordia diagrams in Figures 4 and 5 and listed in Table 1. Complete U-Pb analytical procedures employed at the UBC Geochronology are reported in Mortensen *et al.* (1995).

MAIN ZONE STOCK: CB-HK95-3

The dated sample of the Main Zone stock is a massive, porphyritic quartz biotite plagioclase intrusive

of granodioritic to tonalitic modal composition. The phenocryst phases, plagioclase, biotite and quartz, comprise the majority of the rock (approximately 60 percent). Plagioclase (oligoclase-andesine) phenocrysts are up to 6 mm in length, exhibit oscillatory zoning, have undergone varying degrees of clay-sericite alteration, and make up about 40 percent of the rock. Brown biotite phenocrysts comprise about 10-15% of the rock, are up to 2 millimetres in size, commonly poikiloblastic, containing finer-grained plagioclase, quartz and magnetite, and have been variably altered to chlorite (approximately 10 percent overall). Fresh, anhedral quartz phenocrysts up to 2 millimetres in size make up about 5 percent of the rock. The fine to medium-grained ground mass is made up of approximately equal proportions of plagioclase and quartz (approximately 15-20 percent each) and minor alteration K-feldspar. Accessory phases include magnetite, apatite and zircon.

K-feldspar alteration veinlets about 5 mm in width are cored by pyrite and chalcopyrite. Chalcopyrite and molybdenite coat fracture surfaces.

Abundant, high quality, clear, pale pink, prismatic zircon was recovered from the Main Zone stock. Morphologies vary from stubby prismatic, with aspect ratios of about 1.5:1, to elongate prismatic, with length:width ratios of 5:1.

Three of four analysed zircon fractions (Figure 4, fractions B, C and D) are concordant at approximately 83.5 Ma, and provide the best estimate for the crystallization age of the rock which is $83.5 \pm 0.3 / -0.4$ Ma (Figure 4). Associated errors are derived from the total range of $^{206}\text{Pb}/^{238}\text{U}$ ages for the three concordant fractions. Fraction A, which consisted of the coarsest grained material analysed, exhibits minor discordance and is interpreted to contain a small component of inherited zircon. No cores were observed in these grains.

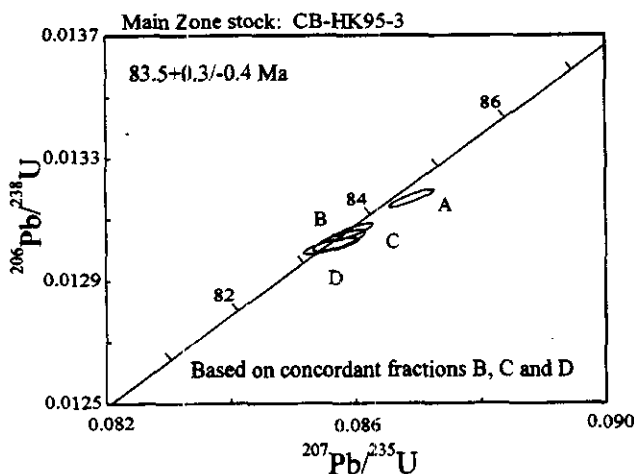


Figure 4. Concordia diagram for the Main Zone stock (CB-HK95-3). Ellipses are plotted at the 2σ level of precision. See text for discussion.

EAST ZONE STOCK: CB-HK95-6

The dated sample of the East Zone stock has been strongly altered and weathered such that little of its primary igneous mineralogy and textures have been preserved. It consists of plagioclase, K-feldspar, quartz and biotite, with abundant pyrite and chalcopyrite on fracture surfaces and coring veins. Malachite and azurite have also been identified in this sample.

Abundant, high quality, clear, pale pink, prismatic zircon recovered from this sample strongly resemble those from the Main Zone stock described above.

Seven analysed zircon fractions indicate a Late Cretaceous age for the East Zone stock. The best estimate for the crystallization age, 83.5 ± 0.3 Ma, is derived from $^{206}\text{Pb}/^{238}\text{U}$ ages for concordant and overlapping fractions A and E (Figure 5). Other fractions appear to contain minor inherited zircon and/or to have undergone post-crystallization Pb loss.

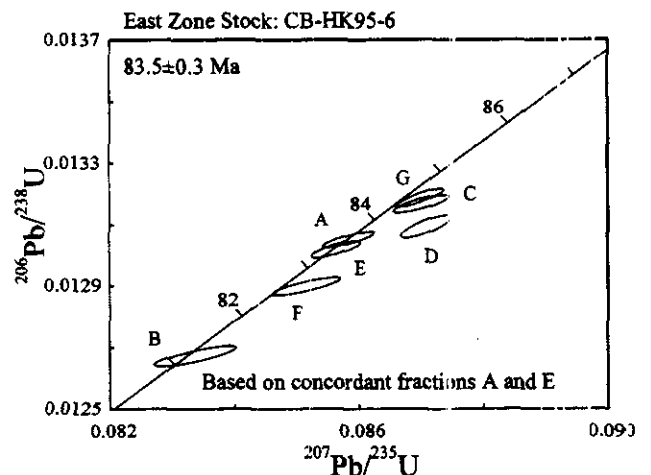


Figure 5. Concordia diagram for the East Zone stock (CB-HK95-6). Ellipses are plotted at the 2σ level of precision. See text for discussion.

DISCUSSION

As presented above, U-Pb zircon ages record the synchronous crystallization and of the Main Zone and East Zone stocks. An overlapping K-Ar biotite cooling age for the Main Zone stock (83.1 ± 3.0 Ma; Christopher and Carter, 1976) indicates a rapid and simple cooling history. This is consistent with the model presented by previous workers in which mineralization, alteration and contact metamorphism at the Huckleberry deposit are related to intrusion of the Main Zone and East Zone stocks (Carter, 1974; James, 1976; Jackson and Illerbrun, 1995). If this model is correct, the U-Pb ages of the Main Zone and East Zone stocks also record the approximate age of mineralization. This may be confirmed by continued sampling and U-Pb dating of post-mineral dykes at the Huckleberry deposit.

TABLE 1. U-Pb ANALYTICAL DATA FOR TWO INTRUSIVE ROCKS FROM THE HUCKLEBERRY DEPOSIT

Fraction ¹	Wt mg	U ² ppm	Pb ³ ppm	²⁰⁶ Pb ⁴ pg	Pb ⁵ %	²⁰⁶ Pb ⁶ %	Isotopic ratios (1σ,%) ⁷			Apparent ages (2σ, Ma) ⁷	
							²⁰⁶ Pb/ ²³⁸ U	²⁰⁷ Pb/ ²³⁵ U	²⁰⁷ Pb/ ²⁰⁶ Pb	²⁰⁶ Pb/ ²³⁸ U	²⁰⁷ Pb/ ²⁰⁶ Pb
Main Zone Stock: CB-HK95-3											
A cc,N1,p,s	0.424	254	3	4043	22	9.0	0.01317 (0.12)	0.0869 (0.21)	0.04786 (0.11)	84.3 (0.2)	92.5 (5.4)
B cc,N1,p,e	0.245	242	3	2891	17	9.5	0.01303 (0.14)	0.0857 (0.25)	0.04772 (0.15)	83.5 (0.2)	85.6 (7.3)
C c,N1,p,s	0.340	286	4	5481	15	8.9	0.01306 (0.11)	0.0859 (0.21)	0.04772 (0.12)	83.6 (0.2)	85.6 (5.8)
D c,N1,p,e	0.175	266	3	1780	22	10.1	0.01301 (0.11)	0.0856 (0.26)	0.04772 (0.18)	83.3 (0.2)	85.2 (8.7)
East Zone Stock: CB-HK95-6											
A cc,N1,p,s	0.181	264	3	2812	14	9.4	0.01305 (0.10)	0.0858 (0.24)	0.04770 (0.17)	83.6 (0.2)	84.6 (7.9)
B cc,N1,p,s	0.246	311	4	543	113	8.7	0.01267 (0.13)	0.0834 (0.40)	0.04772 (0.30)	81.2 (0.2)	85 (14)
C c,N1,p,s	0.154	305	4	1660	24	10.0	0.01317 (0.11)	0.0870 (0.26)	0.04793 (0.18)	84.3 (0.2)	95.7 (8.5)
D c,N1,p,e	0.120	343	5	3028	11	10.7	0.01309 (0.14)	0.0871 (0.23)	0.04824 (0.14)	83.9 (0.2)	111.0 (6.7)
E c,N1,p,s	0.135	282	4	3000	10	9.7	0.01302 (0.11)	0.0856 (0.24)	0.04770 (0.16)	83.4 (0.2)	84.6 (7.6)
F m,N1,p,s	0.230	294	4	942	60	10.1	0.01290 (0.11)	0.0852 (0.32)	0.04788 (0.24)	82.6 (0.2)	93.5 (11.3)
G f,N1,p,e	0.195	285	4	2967	16	10.8	0.01319 (0.12)	0.0870 (0.22)	0.04784 (0.13)	84.5 (0.2)	91.5 (6.1)

Notes: Analytical techniques are listed in Mortensen *et al.* (1995).

¹ Upper case letter = fraction identifier, All zircon fractions air abraded; Grain size, intermediate dimension: cc = > 180µm, c = > 180µm and > 134µm, m = < 134µm and > 104µm, f = < 104µm; Magnetic codes: Franz magnetic separator sideslope at which grains are nonmagnetic (N) or Magnetic (M); e.g., N1 = nonmagnetic at 1°; Field strength for all fractions = 1.8A; Front slope for all fractions = 20°; Grain character codes: b = broken fragments, e = elongate, eq = equant, p = prismatic, s = stubby, t = tabular, ti = tips.

² U blank correction of 1-3pg ± 20%; U fractionation corrections were measured for each run with a double ²³³U-²³⁵U spike (about 0.005/amu).

³ Radiogenic Pb

⁴ Measured ratio corrected for spike and Pb fractionation of 0.0043/amu ± 20% (Daly collector) and 0.0012/amu ± 7% and laboratory blank Pb of 10pg ± 20%. Laboratory blank Pb concentrations and isotopic compositions based on total procedural blanks analysed throughout the duration of this study.

⁵ Total common Pb in analysis based on blank isotopic composition

⁶ Radiogenic Pb

⁷ Corrected for blank Pb, U and common Pb. Common Pb corrections based on Stacey Kramers model (Stacey and Kramers, 1975) at the age of the rock or the ²⁰⁷Pb/²⁰⁶Pb age of the fraction.

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