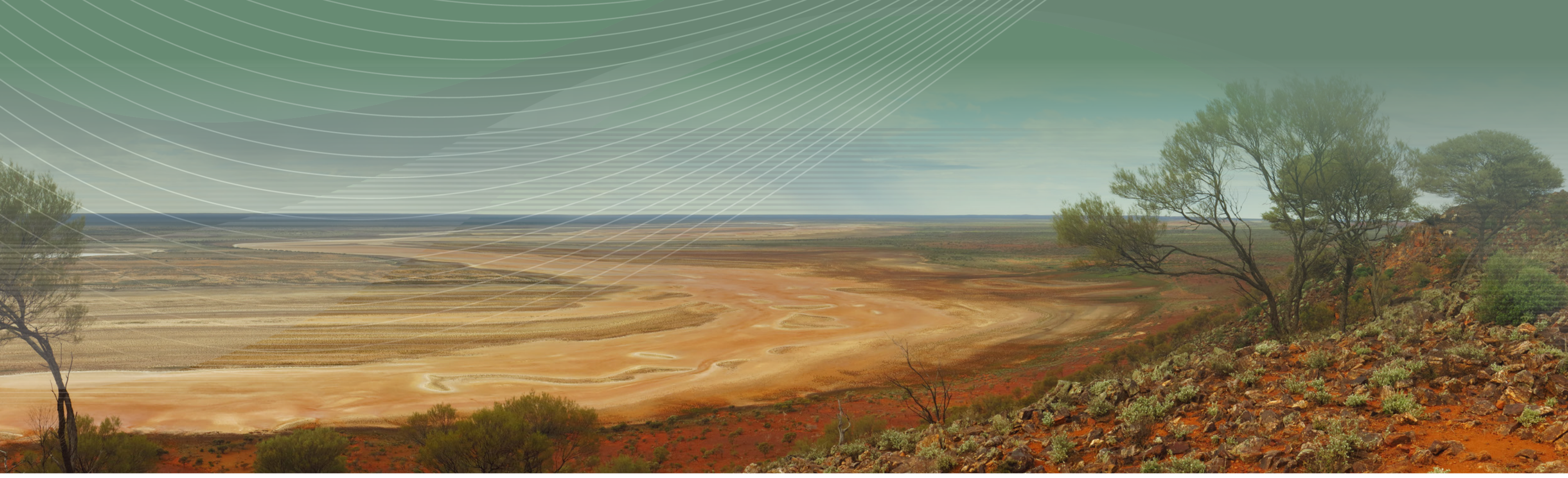
Government of **Western Australia**
Department of **Mines, Industry Regulation and Safety**

RECORD 2018/8

GEOLOGY, RESOURCES AND EXPLORATION POTENTIAL OF THE ELLENDALE DIAMOND PROJECT, WEST KIMBERLEY, WESTERN AUSTRALIA

by
G Boxer and G Rockett



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Geological Survey of Western Australia

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Cover image: Elongate salt lake on the Yilgarn Craton — part of the Moore–Monger paleovalley — here viewed from the top of Wownaminya Hill, 20 km southeast of Yalgoo, Murchison Goldfields. Photograph by I Zibra, DMIRS

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Geology, resources and exploration potential of the Ellendale diamond project, west Kimberley, Western Australia

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G Boxer[1] and G Rockett[2]

Abstract

The Department of Mines, Industry Regulation and Safety (DMIRS) is asking for expressions of interest for the potential reopening of the Ellendale diamond project located in the west Kimberley region of Western Australia. The authors have reviewed the available information and summarized the key geological and resource data to assist industry in considering an investment into this project. Additional details can be found in the references cited in this report. The former mining lease M04/372 has expired. The lease area is currently covered by a *Mining Act 1978,* Section 19 exemption area (S19/368) and this area would be available to any new developer to apply for a new mining lease.

The Ellendale project comprises diamondiferous lamproite pipes and associated diamondiferous alluvial gravels. Two pipes, Ellendale 4 (E4) and Ellendale 9 (E9) have been mined, with a total production of 424 000 carats (ct). Diamondiferous alluvial gravel deposits have also been partly mined adjacent to E9. Mining and processing commenced at E9 in 2004 and ceased in August 2014. Mining at E4 was carried out between 2006 and 2008. Since August 2014, and up until mine closure on 30 June 2015, all diamond production has come from stockpiles. An additional diamondiferous pipe, the E4 satellite pipe (E4S), is unmined. Remaining estimated resources as at 30 June 2015 are 2 075 000 ct (Kimberley Diamonds Ltd, 2015).

A previous owner, Gem Diamonds Limited, carried out a full review of the exploration history, operations and resources at Ellendale in 2011 and compiled a detailed and comprehensive Canadian NI 43-101 technical report (Telfer and McKenna, 2011).

In addition to the estimated resources, there is also exploration potential in the Terrace 5 and E12 Alluvials paleochannels between the western side of the lease area and E9. This area has been drilled, but has had limited bulk sampling to date. There may be other exploration opportunities in the area for additional pipes or extensions, and diamondiferous alluvial gravel deposits. There is a large amount of exploration data available on previous exploration activities both in the lease area and in the adjacent areas.

The main lamproite deposits of Ellendale 4 and 9 have been mined, with the majority of the easily accessible E4 and E9 resources having been extracted. The very high value of the E9 diamonds (approximately US$706/ct) compared with E4 diamonds (US$156/ct) was due to a significant content of 'fancy yellow' diamonds that attracted a price premium. These yellow diamonds were the subject of a special marketing agreement between the former operator and Tiffany Diamonds. The remainder of the diamonds were sold in Antwerp at auction.

Although the diamond value of the E4 diamonds was lower than the E9 diamonds, the grade at E4 was significantly higher than the grade at E9. Pipe E4S is unmined and resources are estimated at 13 Mt at 5.5 carats per one hundred tonnes (cpht). Note that the eastern part of the E4S pipe is currently covered by the Devonian Reef Conservation Park (Reserve 43099). In accordance with existing Western Australian Government policy, exploration and mining are allowable activities in such reserves.

Detailed geological and mine-planning data from the Kimberley Diamond Company (KDC) were not available at the time of writing this report. The openpits at E4 and E9 are flooded and access is currently blocked for safety reasons. Run-of-mine (ROM), floats and low-grade stockpiles remain at plant sites located near E4 and E9. Much of the plant and equipment has been sold and removed from site. The existing mine camp and its infrastructure have also been sold.

Additional resources may be discovered by further exploration, including the Terrace 5 gravels, potential tuff ring remnants around E7 and E9, and additional alluvial channels adjacent to E4. However, due to the large amount of previous exploration, it is the opinion of the authors that it is unlikely that a large lamproite remains undiscovered in the lease area.

An exploration target that appears to have been overlooked is the occurrence of possible remnant and reworked tuff rings that would have formed around all lamproite vents during their eruptive stages. Many of the vents have large amounts of magmatic lamproite filling their vents. This magmatic lamproite has a very low diamond grade, and is usually the last phase of eruption. This final stage of eruption does not preclude the occurrence of diamondiferous tuffs that could have been erupted earlier in the evolution of the vents. These potentially diamondiferous tuffs would have formed tuff rings around the vents and may be preserved, or have been reworked into eluvial or adjacent alluvial deposits, or both.

KEYWORDS: alluvial deposits, Canning Basin, diamonds, Ellendale, Kimberley, lamproite, Western Australia

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Introduction

The Ellendale diamond project (Ellendale project) is located 130 km east of Derby in the west Kimberley region of Western Australia (Fig. 1). Diamonds were first recovered in the area in the 1970s, and it was the Ashton Joint Venture (AJV) that led to the discovery of lamproitic diamonds in the Big Spring area to the east of the Ellendale project. Follow-up exploration and evaluation led to the identification of two significantly diamondiferous pipes, Ellendale 4 (E4) and Ellendale 9 (E9). The diamonds are hosted in olivine lamproite volcanic pipes in contrast to most of the world's diamond production that is hosted in kimberlite pipes.

The AJV determined that Ellendale pipes 4 and 9 contained significant quantities of diamonds, but the grades were not sufficient to establish a diamond mining operation at that time (1980). The Ellendale mining lease (M 04/372) was granted to Argyle Diamond Mines (formerly the AJV) with a start date of 23 November 1999, and was subsequently purchased by the Kimberley Diamond Company in 2001. KDC commenced mining in 2002, initially on the surface-enriched regolith of E9, followed by mining of lamproite at E4 and E9. Mining was suspended at E4 in 2008 and E9 in 2014. KDC, in association with Blina Diamonds NL (Blina), carried out exploration for lamproite pipes and diamondiferous alluvial gravels on the mining lease and on adjoining areas. Numerous reports of exploration activities are available as open-file reports via the Department of Mines, Industry Regulation and Safety (DMIRS) WAMEX web portal.

Ownership of KDC changed in 2007 when it was purchased by Gem Diamonds Limited, and again in 2013 when it was purchased by Goodrich Resources and renamed Kimberley Diamonds Ltd (KDL), which was listed on the Australian Securities Exchange (ASX). KDC, a subsidiary of KDL, went into receivership on 1 July 2015. With the corporate collapse of KDC, DMIRS created a special reserve under the *Mining Act 1978* (Section 19/368) covering the old mine lease area to prevent the area being pegged as a new exploration or mining tenure (Fig. 2). DMIRS aims to obtain expressions of interest from potential new operators of the Ellendale diamond project and would relinquish the Section 19 lease to allow the successful bidder to apply for a new mining lease.

This report draws on the authors' personal experience working in the area and from reports by previous operators in the Ellendale project area. Telfer and McKenna (2011) and the Kimberley Diamonds Ltd ASX announcements contain a significant amount of relevant information on the current resources and the methods of resource estimation. Telfer and McKenna (2011) was used extensively for the more recent resource descriptions and resource calculation procedures in the current report. Detailed geological models, mine planning and development information used during the mining operations were not available at the time of writing of this report.

All UTM coordinates in this report are GDA94 Zone 51.

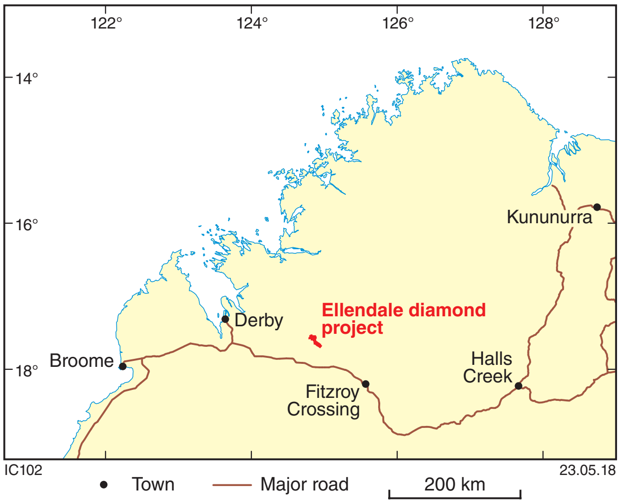

Figure 1. Ellendale project location map

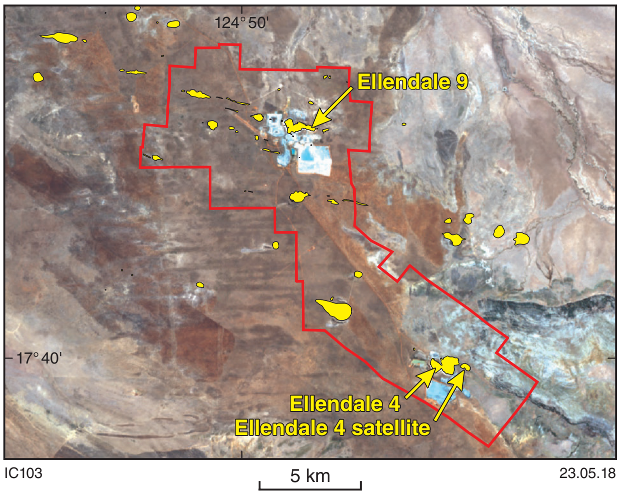

Figure 2. Ellendale project area showing *Mining Act 1978* Section 19/368 lease and Ellendale pipes 4 and 9 (Google Earth image)

Property description and location

The Ellendale project area comprises a *Mining Act 1978* Section 19/368 area representing the expired M04/372 lease area and is located 130 km east of the town of Derby in the west Kimberley region of northern Western Australia (Fig. 1). The project area is centred at latitude 17°36'S, longitude 124°52'E.

Accessibility, climate, local resources, infrastructure and physiography

Access to the area is primarily via Derby and along the Gibb River Road for 110 km to the access road into the project area. Regular air services are available to Broome and hire cars are available for road travel to Derby. A 4WD is recommended as roads in the project area are unsealed. A gravel airstrip is located at the mine site, but its current serviceability is unknown. The main access road into the project area is Roberts Road, which runs southeast from the

Gibb River Road. The E9 plant site and airstrip are located 23 km southeast from the turn off. All access gates into the project area are currently locked.

The climate of the area is semi-arid monsoonal, characterized by warm dry winters and hot wet summers, with maximum temperatures during the wet season exceeding 38°C (Griffin et al., 1993). The project area forms part of the Fitzroy Plains physiographic province, which includes the Lennard River floodplains interspersed by small hills (lamproite plugs and sandstone remnants) up to 90 m high.

History

Diamonds were first reported from the area in 1968 when a consortium comprising Exoil NL, Transoil NL and Petromin NL collected samples from the Lennard River at Police Camp Pool to the northwest of the Ellendale project area. They recovered nine diamonds weighing 1.65 ct (Haynes, 1971). The interest in diamond exploration in the area was inspired by the presence of leucite lamproites in the area and their possible association with diamonds (Wade and Prider, 1940; Prider, 1960). Magnetic anomalies were noted by the exploration consortium, but none were followed up in the field.

The discovery of the diamondiferous nature of the lamproites was the result of systematic exploration of the greater Kimberley area by the AJV and its predecessor the Kalumburu Joint Venture (Atkinson et al., 1985). Stream-sediment sampling for diamond (kimberlite) indicator minerals in the Leopold Downs area, to the east of the Ellendale project, in 1976 led to the discovery of the diamondiferous Big Spring lamproite pipe (Hughes and Smith, 1990). A gravel sample from a tributary of the Mount North Creek, adjacent to the Ellendale project, recovered chromite, pyrope and diamond. The initial pipe discoveries were numbered according to their aeromagnetic anomaly number, for example Ellendale 9 (E9), and later discoveries by KDC were numbered using Kim numbers (‘Kim’ after Kimberley Diamond Company). At E4, anomalous circular shapes on aerial photographs were associated with weak magnetic features, and a subsequent aeromagnetic survey of the area quickly located the majority of the lamproite pipes.

Extensive exploration was carried out on all of the known pipes between 1977 and 1980, resulting in E9 and E4 being identified as the most prospective. The pipes are large, but low grade, and the project was put on care and maintenance in 1980 after the AJV discovered the much richer Argyle pipe in the east Kimberley region. Argyle Diamonds Mines Pty Limited (Argyle Diamonds) was created to undertake the operations at Argyle and Ellendale. The AJV continued exploration outside of the Argyle and Ellendale areas. Argyle Diamonds carried out feasibility studies in 1989 and 1990 with a large-diameter drill-sampling program at E4 to test the diamond grades in the southeast lobe of E4 (Argyle Diamond Mines Pty Limited, 1990; Boxer and Herrera, 1990; Boxer, 1991). Results of these studies indicated that the grades were too low to support a viable mining operation at that time.

In 2001, the Ellendale project tenements were sold to KDC, with the mining lease being transferred in 2002. KDC carried out extensive exploration and evaluation studies on pipe and alluvial deposits and these have been summarized in WAMEX reports for M04/372. Mining and processing commenced at E9 in 2004 and ended in August 2014. Mining at E4 was carried out between 2006 and 2008. Since August 2014, all diamond production has come from stockpiles.

Geological setting and mineralization

The Ellendale lamproite field (Ellendale field) forms part of the west Kimberley lamproite province and contains approximately 90 lamproite intrusions of varying sizes. The largest intrusion in the Ellendale field is E6 at 107 ha. The lamproites have been dated at c. 22 to 18 Ma (Jaques et al., 1984) and range in composition from leucite lamproite to olivine lamproite. The geological setting and descriptions of the lamproites of the Ellendale field have been documented by Jaques et al. (1986) and Hughes and Smith (1990). Erosion of the diamondiferous lamproites has distributed diamonds into adjacent streams and led to the formation of a number of alluvial diamond deposits.

The generalized geology of the lamproite intrusions comprises a flared or champagne-shaped vent with a margin of sand-rich tuffs, vent-filling lapilli ash tuffs and a central core of intrusive porphyritic lamproite (Fig. 3). The highest diamond grades are found in the tuff phases of the olivine lamproite pipes, with the leucite lamproites typically being of very low diamond grade or barren of diamonds. The magmatic olivine lamproite is typically very low grade. Diamonds are accidental inclusions in the lamproite magma, with diamonds being derived from depths of about 150–200 km and carried to the surface where they have erupted in small volcanoes. Recent discussions on the origins of diamonds and diamond formation can be found in Stachel and Luth (2015).

The lamproite pipes of the Ellendale field are the eroded remnants of volcanoes that are interpreted to have formed in a terrestrial environment, with upwelling lamproite magma intersecting water-saturated sandstones of the Late Carboniferous to Early Permian Grant Group. The magma–water interaction was responsible for producing explosive phreatomagmatic eruptions (Smith and Lorenz, 1989). This style of eruption has been described from various parts of the world and has been well studied (Lorenz et al., 2016). The eruptions excavated a large flaring vent, with the early volcanic deposits being a mix of sand and lamproite tuff followed by lamproite tuff with only minor sand, and further followed by a more passive phase of eruption where molten lamproite magma was intruded up into the crater to form a lava lake. Some pipes contain multiple eruptive episodes, thus creating a complex internal geology. Mixing of the tuffs and lava-lake magmatic rocks formed a transition zone at the boundary of these rock types. The lamproite volcanoes have been eroded approximately 30–90 m below the original surface level at the time of emplacement. Erosion of the pipe and surrounding tuff ring has distributed abundant lamproite detritus into the local drainages and is thought to be the major source of the diamonds found in Terrace 5 and other diamondiferous alluvial channels.

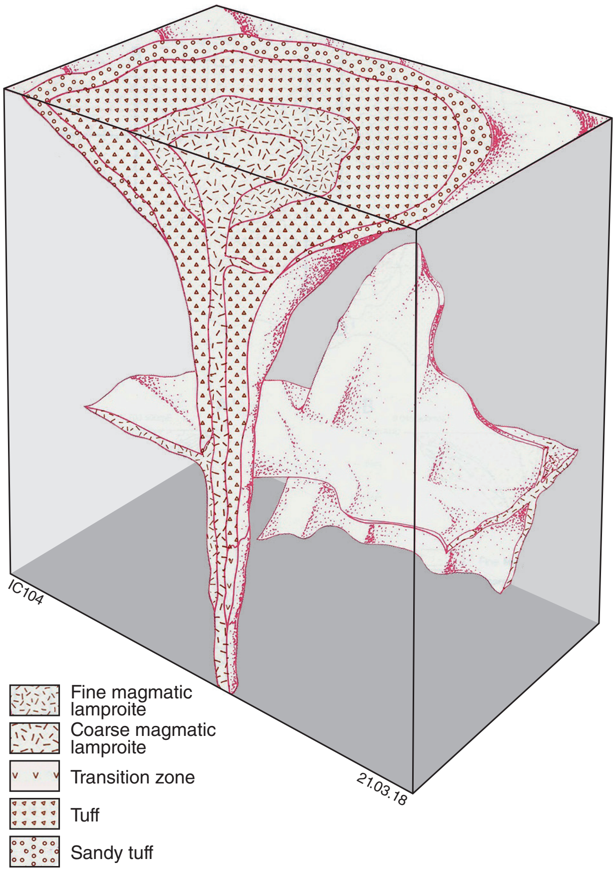

Figure 3. Simplified model of a lamproite pipe (after Boxer, 1991)

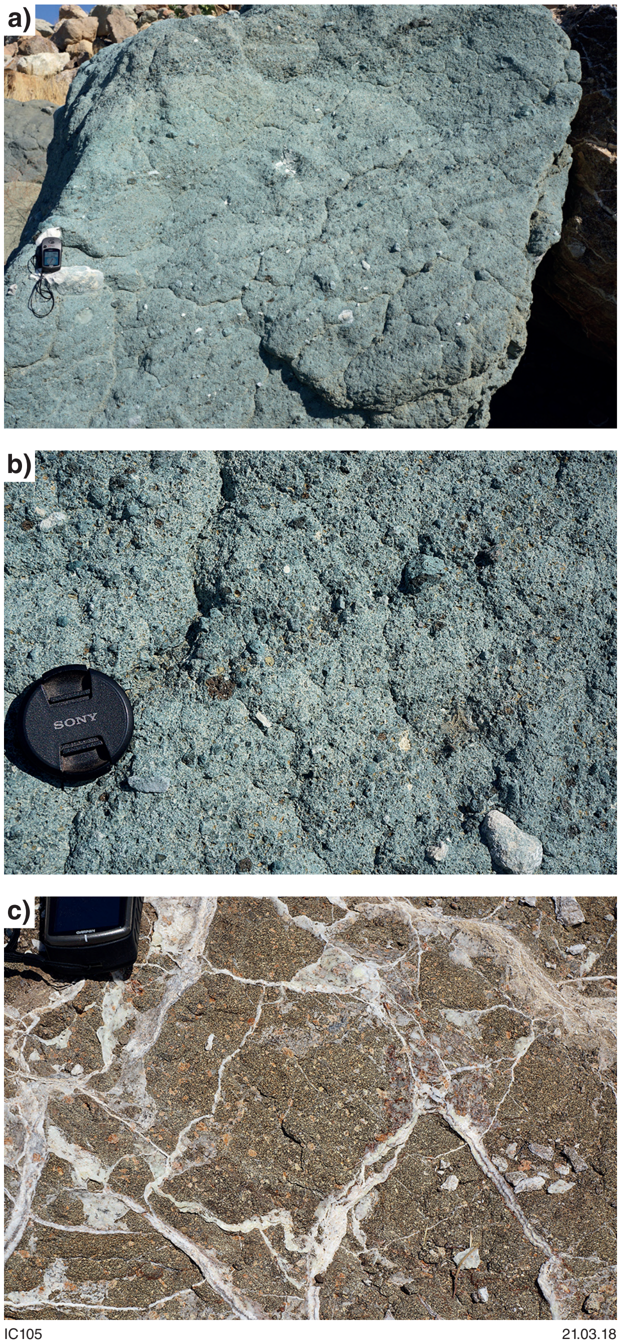

Figure 4. a) Bedded lapilli ash tuff (ULT) in the E9 pipe (photo by G Boxer); b) close-up of bedded tuff (ULT) in the E9 pipe (photo by G Boxer); c) magmatic lamproite (ULM) veined with calcite in the E4 pipe (photo by G Boxer)

The most recent KDC mining terminology for the Ellendale field is as follows:

- **High-grade ore**: comprises the ultramafic lamproite tuff (ULT; Fig. 4a,b), the sandy tuff (ULTS; containing > 15% quartz sand) and ultramafic brecciated tuff (UBX);
- **Low-grade ore**: comprises the volcanic finer grained transitional-tuff facies (ULTtrans) found adjacent to ultramafic magmatic lamproite (ULM) and tuffaceous sandstone or highly quartzitic tuffs (TS); and
- **Internal and external waste rock**: comprises ULM (Fig. 4c), intrusive and extrusive magmatic dykes and plugs, and the surrounding pipe wallrocks composed of sandstone of the Grant Group (SST) and siltstone of the Fairfield Group (SSL).

The diamond content of the lamproite pipes of the Ellendale field varies from barren, typically the olivine-poor, leucite-rich varieties, to significantly diamondiferous that is typical of the olivine-rich and leucite-poor varieties. Early exploration indicated that E4, its satellite pipe (E4S), and E9 contained the highest diamond grades, and consequently these pipes have been the focus of much of the exploration, evaluation and mining activities. Sampling has indicated that the highest grades were confined to the tuffs, with the sand-bearing tuffs and magmatic lamproite being of lower grades.

Lamproite pipe deposits

Pipe exploration

During the late 1970s and 1980s, exploration for lamproite pipes involved the follow-up of aeromagnetic anomalies by ground magnetic surveys; loam sampling for diamond indicator minerals; geochemical soil sampling; auger, aircore, rotary air blast (RAB) and reverse circulation (RC) drilling (Fig. 5); and geochemical analysis. Scout sampling for diamonds was carried out using a combination of bulldozer, excavator, Hughes auger, and Wirth large-diameter (0.8 m) drilling rigs, which were used extensively in the pipe evaluation and alluvial channel delineation (Figs 6–8). Further exploration included detailed airborne and ground electromagnetic methods, airborne gravity, and soil and termite-mound geochemical sampling. Figure 9 shows the location of drillholes on the former mining lease and adjacent areas.

Exploration by KDC in 2000 concentrated on the Terrace 5 paleoalluvial channel system. A number of other lamproite pipes, for example E6, E7, E10, E11, E12, E13, E14, E19 and E46, within the former mining lease area were re-examined by KDC and the details reported in their annual reports (available in the WAMEX database). Figure 10 shows the location of bulk samples collected by KDC and Blina Diamonds outside of the known Ellendale lamproite pipes.

Detailed geochemical termite-mound sampling has highlighted the dispersion of Nb in the soils and can potentially be used to explore for alluvial channels and eroded tuff-ring deposits. Figure 11 shows the dispersion of Nb in the termite-sampling data and highlights the haloes around the pipes and elevated values along the Terrace 5 drainage system.

IC106 21.03.18

Figure 5. Exploration RAB drilling (photo by G Boxer, 1979)

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Figure 6. Wirth large-diameter drill sampling (photo by CB Smith, 1979)

IC108 21.03.18

Figure 7. Hughes auger undertaking scout bulk sampling (photo by G Boxer, 1979)

IC109 21.03.18

Figure 8. Large-diameter (1.4 m) drill sampling of the E4 pipe (photo by G Boxer, 1990)

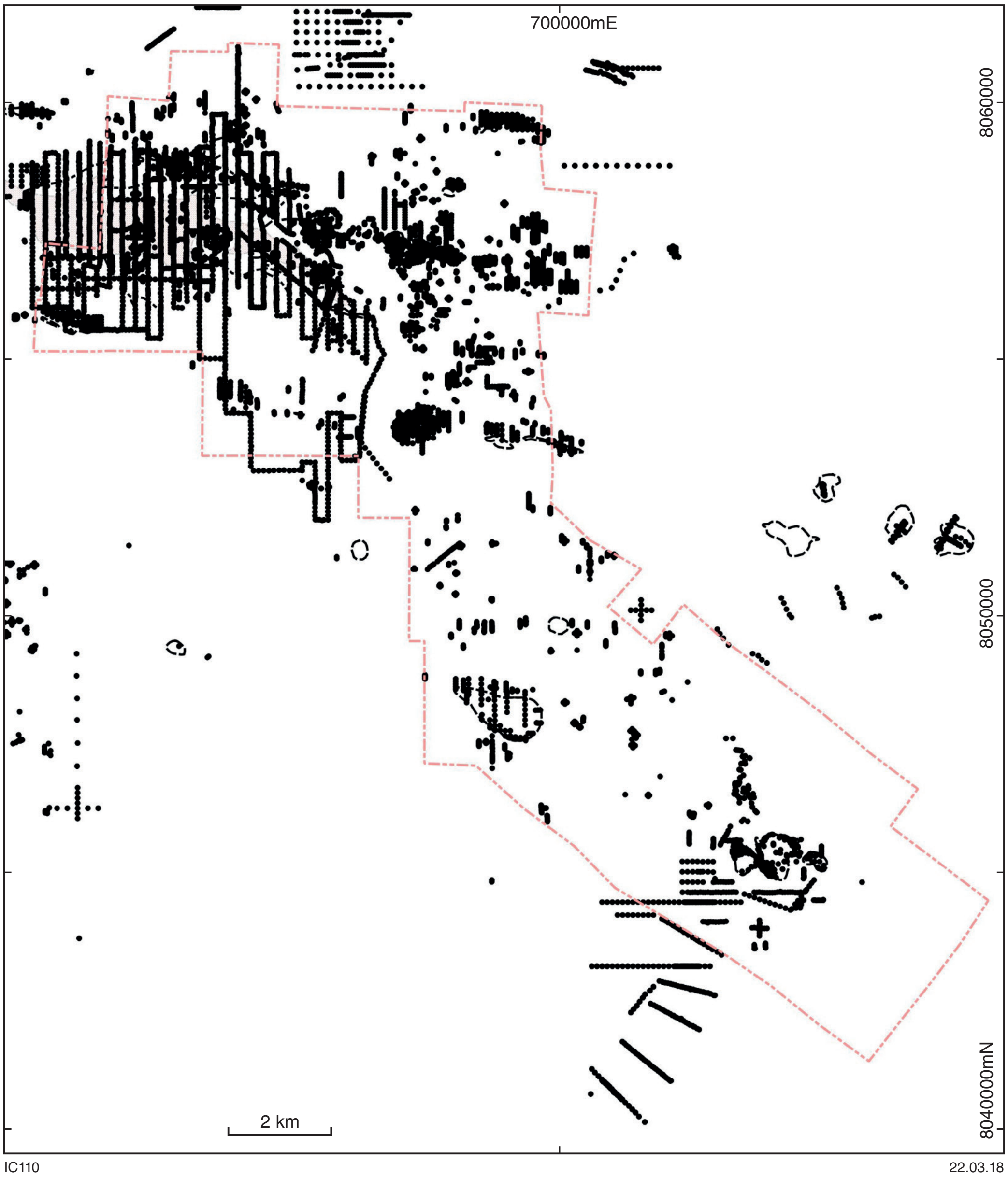

Figure 9. Ellendale mining lease drillhole locations

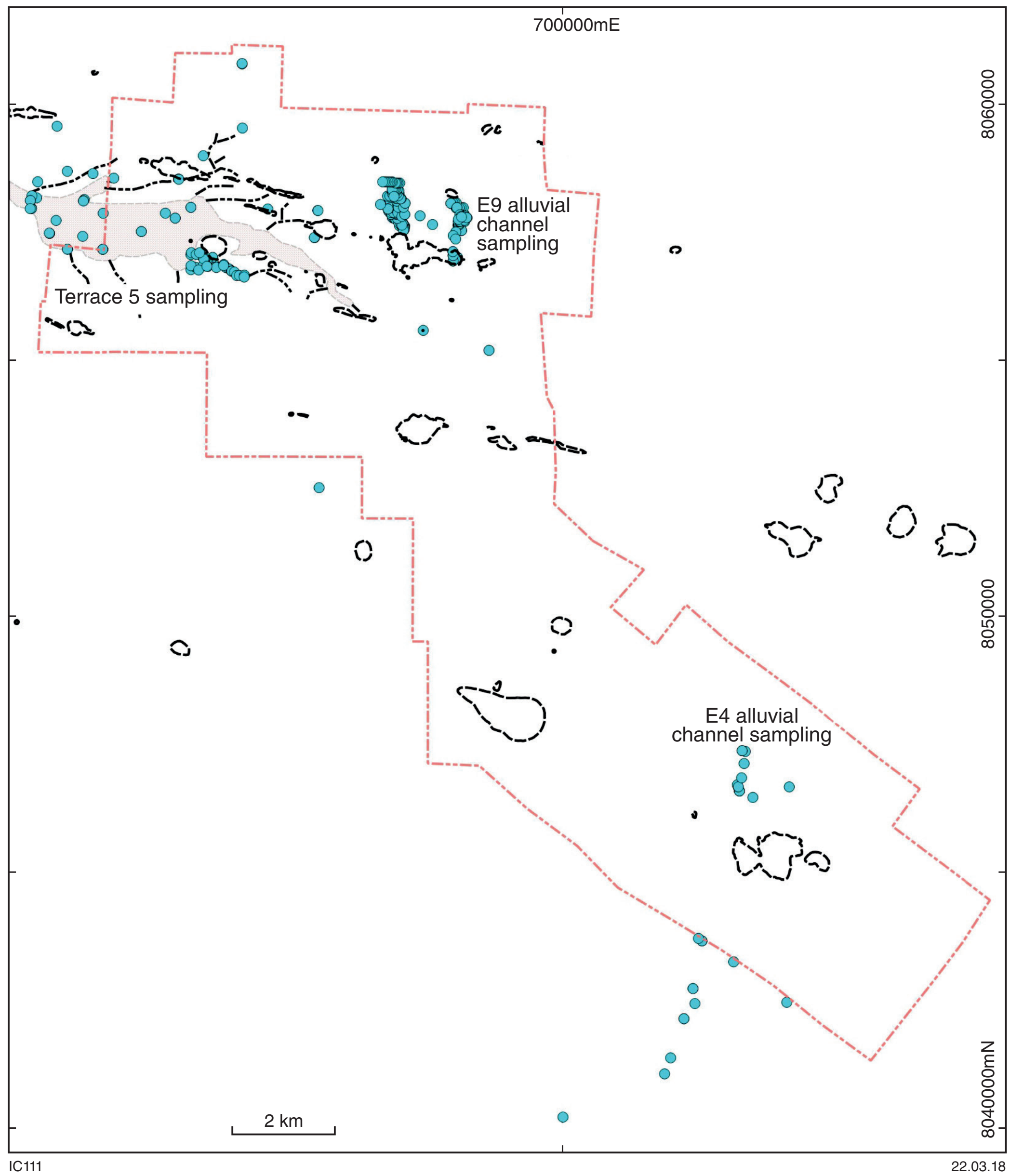

Figure 10. KDC and Blina Diamonds bulk-sample locations, Ellendale mining lease

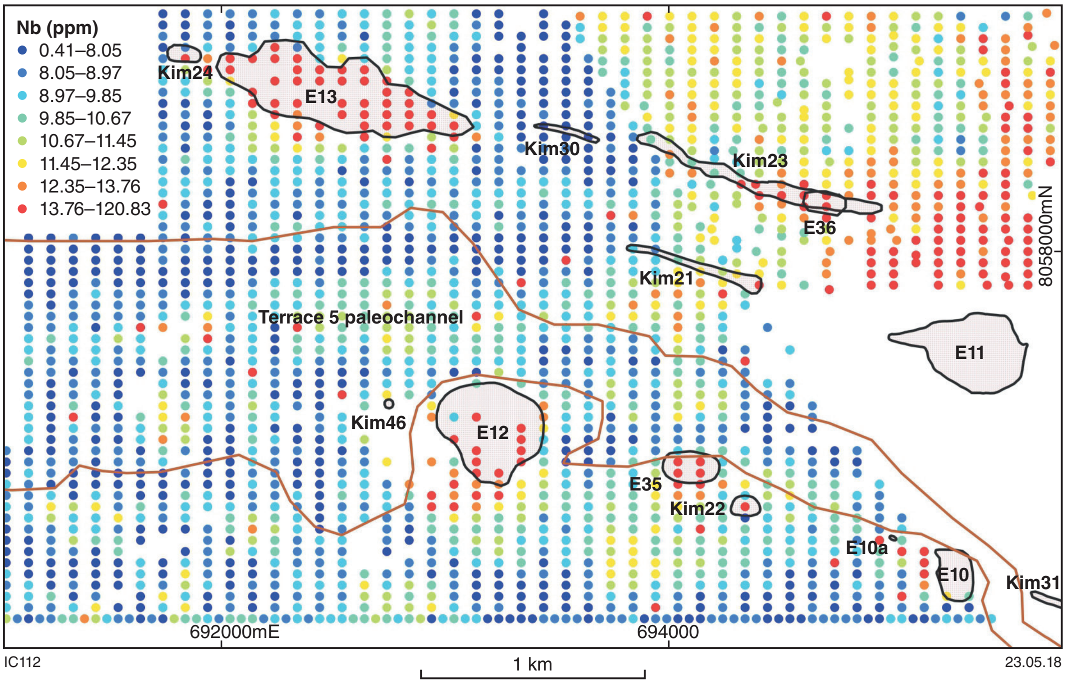

Figure 11. Nb results of termite-mound sampling showing lamproites and Nb dispersion around the pipes and along the paleodrainages

A number of aeromagnetic surveys have been flown over the area and these are listed in DMIRS' online airborne geophysical survey index, the Mineral and Airborne Geophysics Information eXchange (MAGIX). The most detailed line spacing (50 m) was flown in a north–south direction (Blina 2 MAGIX registered survey no. 60482, open file) between E9 and E4. The northwestern corner of the lease is covered by 50-m line spacing aeromagnetic data (Ellendale 1994 Area 1, MAGIX registration no. 60054, open file). An airborne electromagnetic (EM) survey (Tempest, MAGIX registration no. 60719, open file) has also been acquired over the area with a line spacing of 100 m. Aeromagnetic data identified the majority of the lamproite pipes (Fig. 12), and the Tempest EM has highlighted the larger lamproite occurrences (Fig. 13). The EM data may also be useful to trace alluvial channels such as the Terrace 5 paleochannel.

Due to the extensive exploration work carried out over the Ellendale project area, it is unlikely that a large undiscovered lamproite pipe is present in the lease area. An exploration target that does appear to have been overlooked is possible remnant and reworked tuff rings that would have formed around all lamproite vents during their formation. Many of the vents have large amounts of magmatic lamproite filling their vents. This magmatic lamproite has a very low diamond grade and is usually the last phase of eruption. This final stage of eruption does not preclude the occurrence of diamondiferous tuffs that could have been erupted earlier in the evolution of the vents. Surface bulk sampling of this low-grade magmatic lamproite may have downgraded the pipe's potential, with the grades of diamondiferous tuff, both under the magmatic lamproite and in any possible adjacent tuff ring deposits, being untested. These potentially diamondiferous tuffs may be preserved or reworked into eluvial or adjacent alluvial deposits, or both.

Ellendale pipe 4 (E4)

Ellendale pipe 4 is located in the southeastern part of the former mining lease area and is one of the largest lamproite pipes in the Ellendale field, with an area of approximately 76 ha. E4 has intruded into sandstone of the Grant Group and limestones of the Late Devonian Nullara and Windjana Limestones. Figure 14 illustrates the geology around E4 and the location of other lamproites in the area. Some of the sandstones mapped around pipes E4 and E6 may be, in part, the original tuff rings surrounding these vents.

Drilling of the E4 pipe has identified a complex internal geology formed from the coalescence of at least three volcanic vents. The internal geology as interpreted from drilling by the AJV, and KDC after additional drilling and mining, respectively is shown in Figures 15 and 16. The current pits are shown in Figure 17. The remaining resources lie in the N West lobe and the SW East lobe. Estimated remaining resources at E4 are 4.0 Mt at 6.7 cpht (indicated) and 10.3 Mt at 6.1 cpht (inferred; Kimberley Diamonds Ltd, 2015). Detailed mine plans showing pit details, sampling and resources were not available at the time of this report.

Ellendale pipe 4 satellite (E4S)

Ellendale pipe 4 satellite, the satellite pipe to E4, has a surface area of approximately 8 ha and is currently unmined (Fig. 18). The pipe comprises magmatic olivine lamproite overlying olivine lamproite tuff (Figs 19–21), and KDC estimated that the pipe contains an inferred resource of 13.1 Mt at 5.5 cpht for an estimated contained 725 000 ct, with an average value of US$210/ct (Kimberley Diamonds Ltd, 2015). Detailed mine plans showing pit details, sampling and resources were not available at the time of this report.

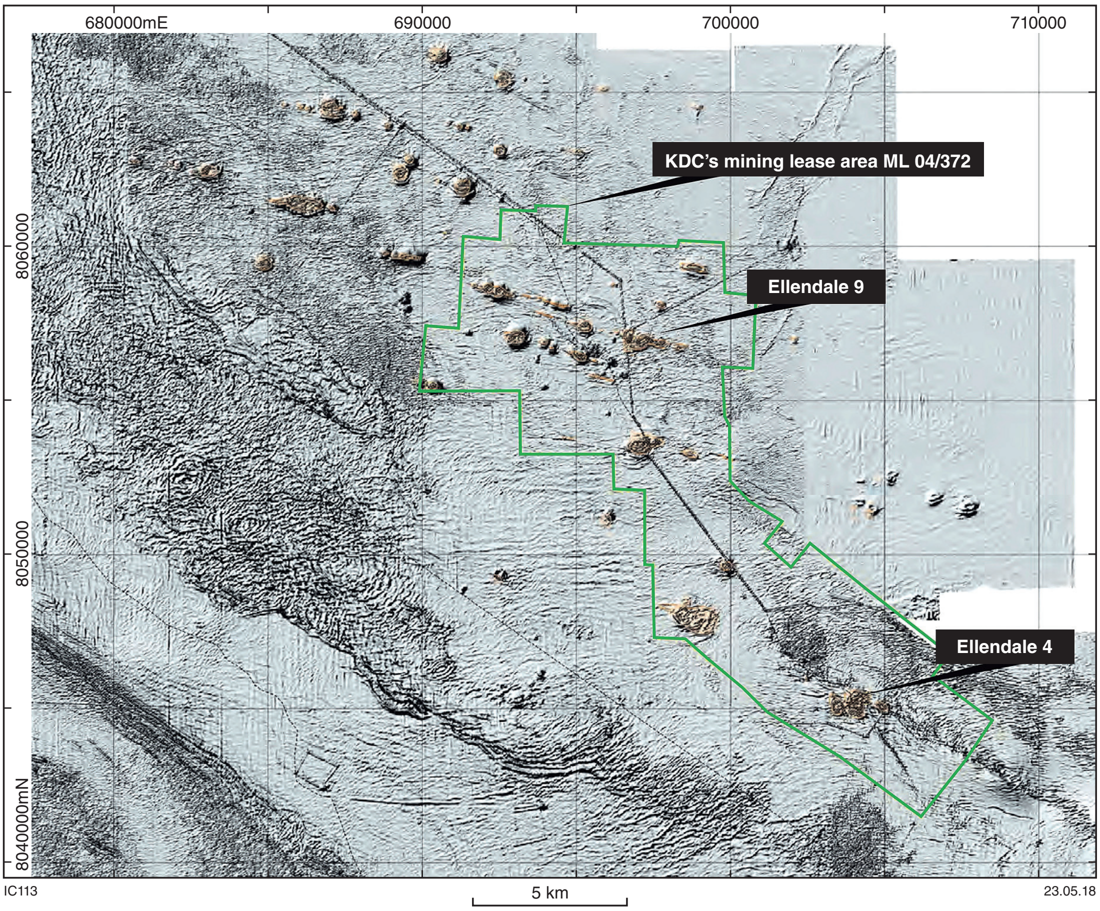

Figure 12. Aeromagnetic data for the Ellendale area (after Telfer and McKenna, 2011)

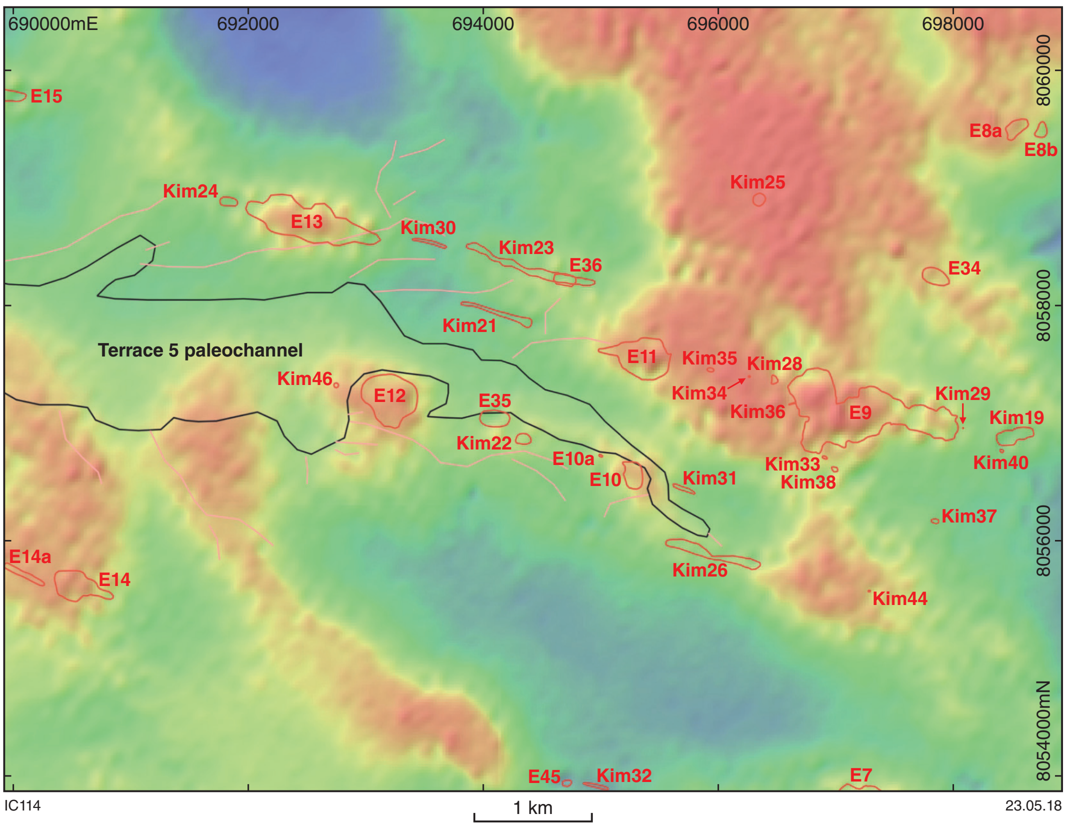

Figure 13. Airborne TEMPEST EM data showing the location of lamproites and the Terrace 5 paleochannel. Areas of high clay (e.g. pipes and black-soil plains) show up as conductive areas (red)

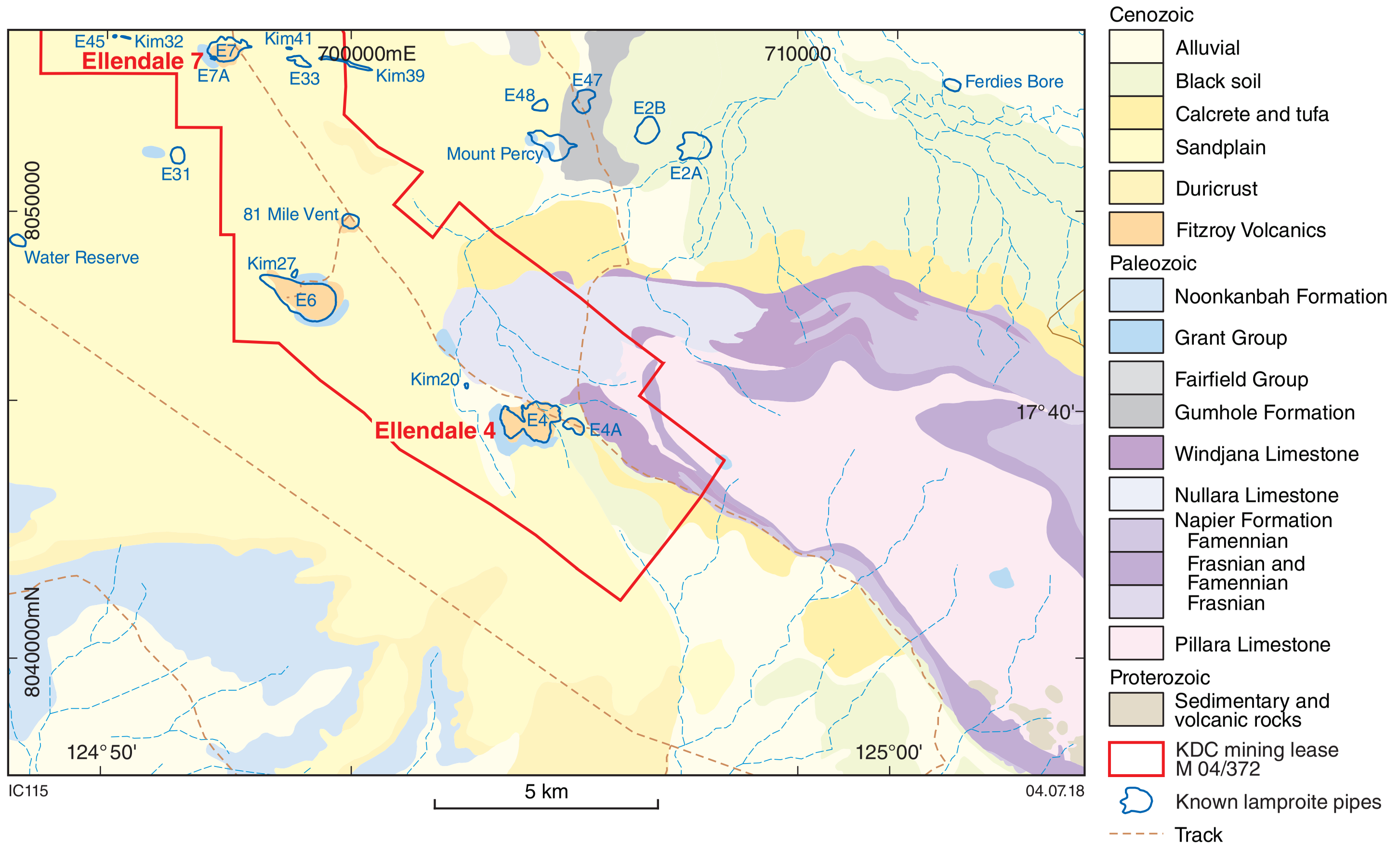

Figure 14. Geology of the area around E4 showing the lamproite pipes (modified from Griffin et al., 1993)

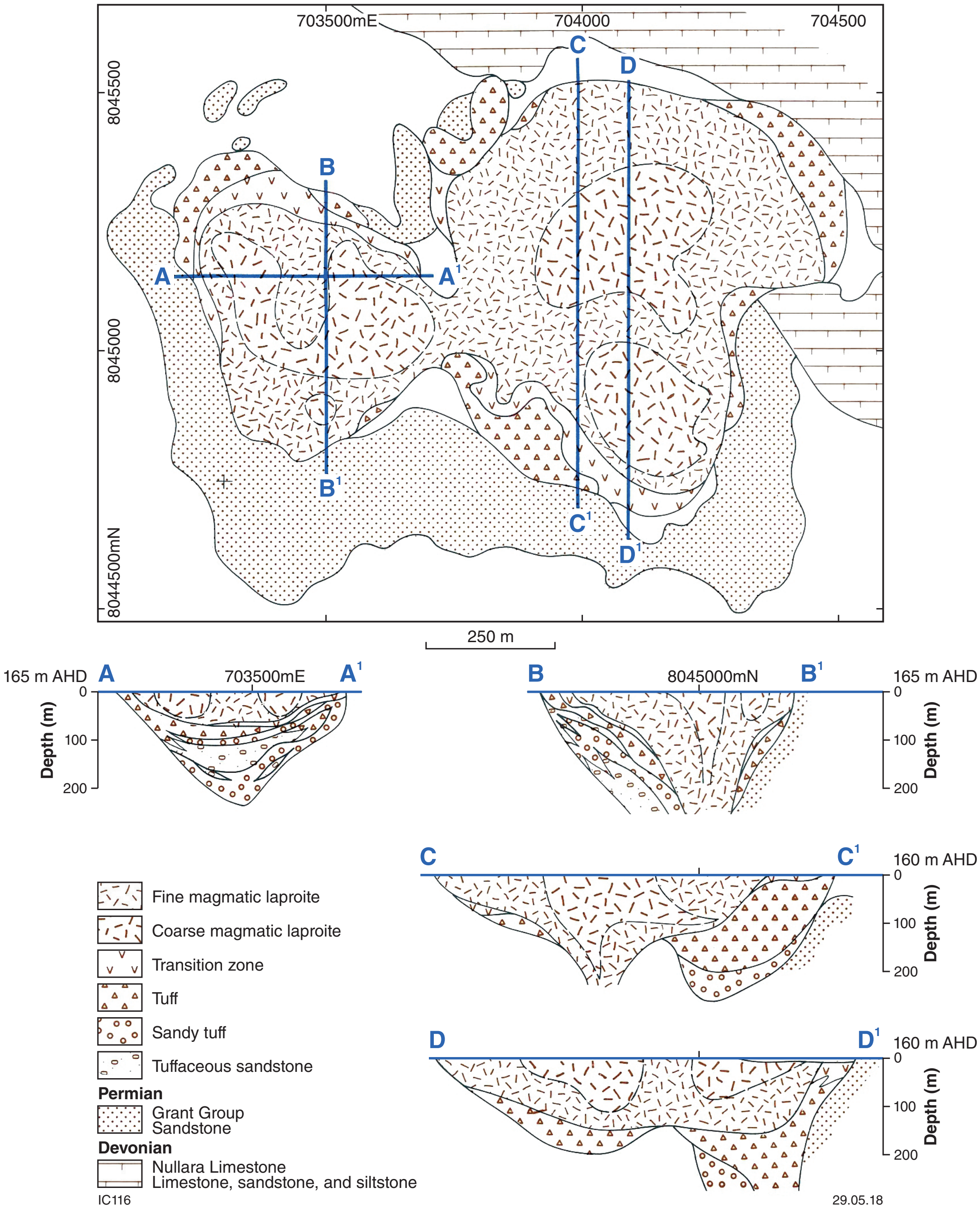

Figure 15. Pre-mining interpreted surface geology and simplified cross-sections through E4 (after Boxer, 1991)

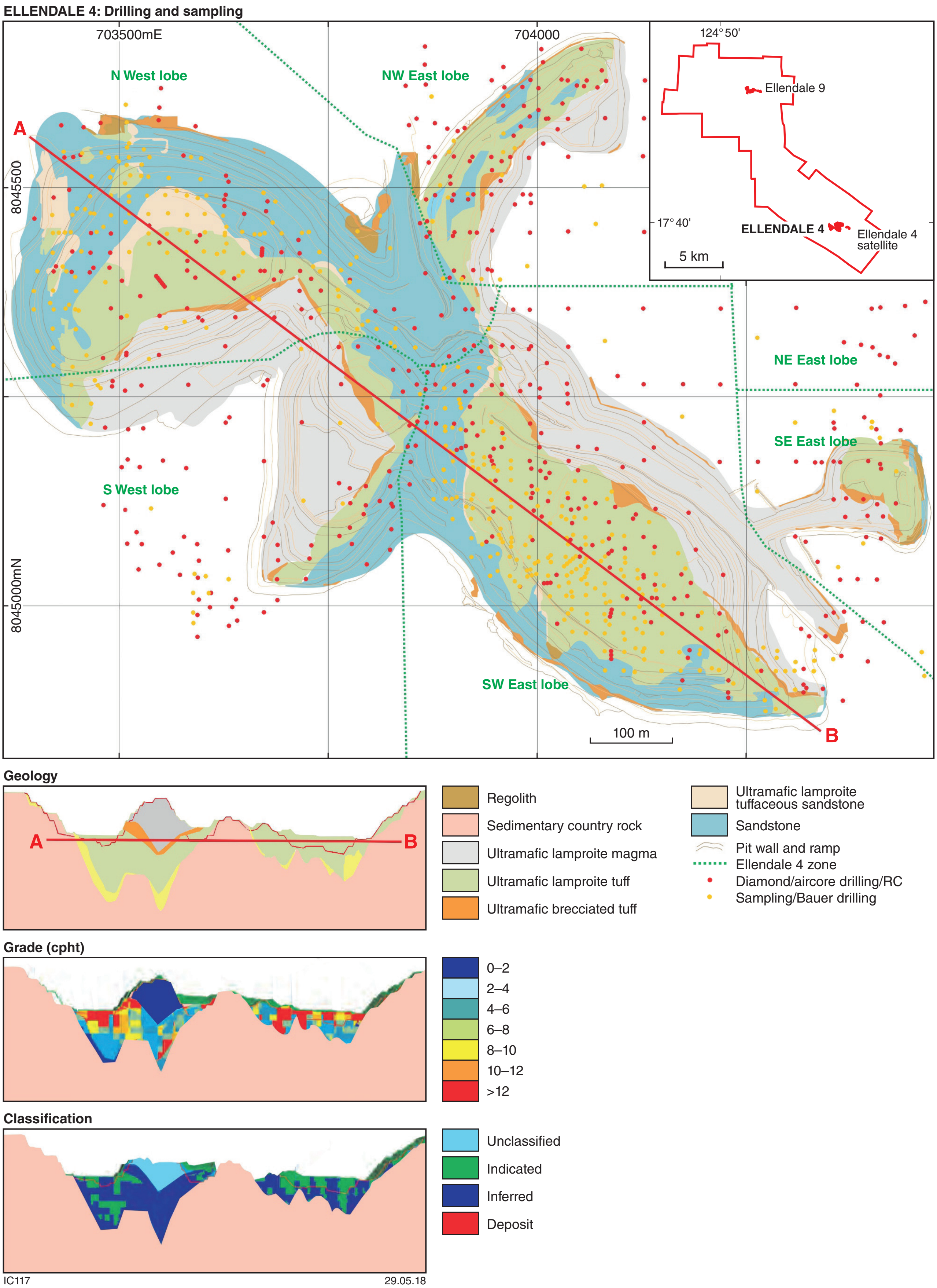

Figure 16. Drilling and sampling at E4 and cross-sections showing the geology, grade and resource classification for E4 (after Telfer and McKenna, 2011)

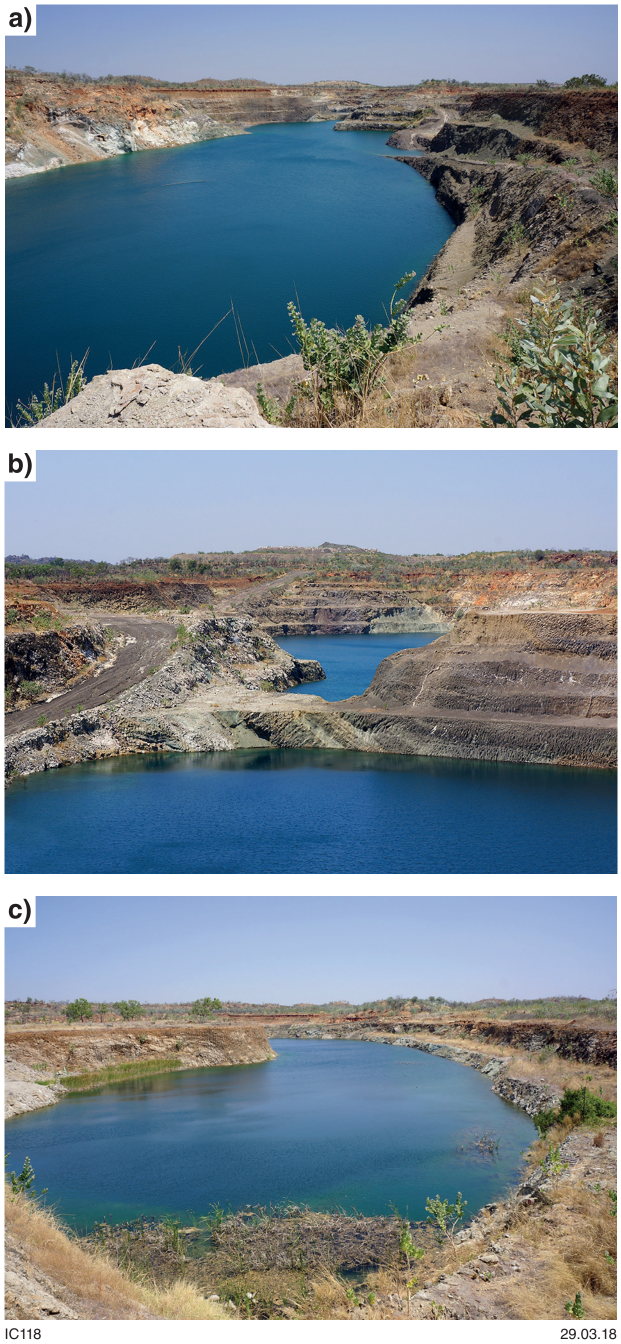

Figure 17. **a) E4 pit view to the northwest from the southern area of the SW East lobe (photo by G Boxer); b) E4 pit view to the southeast from the northwestern area of the N West lobe (photo by G Boxer); c) E4 pit view to the southwest from northern area of the NW East lobe (photo by G Boxer)**

Ellendale pipe 9 (E9)

Ellendale pipe 9 (E9) has been the focus of most of the mining and processing in the Ellendale field. E9 is a large 47-ha complex lamproite pipe, with the western lobe measuring approximately 700 × 350 m and the eastern elongated area measuring approximately 1000 × 400 m (Figs 22, 23). The tuffs are partly overlain by magmatic olivine lamproite, which has been removed and considered waste. Estimated remaining resources at E9 are 5.1 Mt at 3.7 cpht (indicated) and 1.4 Mt at 3.5 cpht (inferred; Kimberley Diamonds Ltd, 2015). Detailed mine plans showing pit details, sampling and resources were not available at the time of this report. The current pits are shown in Figure 24.

Diamondiferous alluvial deposits

A number of diamondiferous alluvial deposits have been discovered in the project area, with only the E9 North western and eastern channels being mined extensively to date.

Terrace 5

The Terrace 5 paleochannel, which is the largest of the alluvial diamond prospects within the former Ellendale mining lease (Fig. 13), was discovered by Kimberley Diamond Company NL in 1994 (Jones, 1994; Lanham and Jones, 1996). The paleochannel is an ancient buried river system, possibly of Miocene age, which extends more than 35 km. The Terrace 5 system drained the central section of the Ellendale field, including the E9 and E12 pipes, and has been explored for approximately 30 km to the west of the mine lease area. A portion of the diamonds recovered appears to have not been derived from any of the known lamproites within the catchment, suggesting there may be an additional undiscovered source.

Diamond grades range up to 15.85 cpht, with many samples containing between 4 and 6 cpht. The gravels contain significant quantities of diamonds of large average size (approximately 0.4 ct). Most diamonds are of gem quality, with the population dominated by white diamonds. The largest diamond recovered from Terrace 5 weighed 8.44 ct, with stones larger than 2 ct being common.

Geology

Terrace 5 was the major drainage system of the area and comprises a main channel and various tributaries. The channel is typically 200–500 m wide and gravels, where present, average between 0.25 and 1 m in thickness. Valley-fill sediments and wind-blown sand overlie the gravels to depths of up to 15 m, and the sequence provides evidence for dramatic climate change over the last 20 million years. The main channel is generally deeply incised with steep sides. Tributaries feed into the system from both the north and south, with older terraces running subparallel to the main channel. The headwaters of this river system lie within the central portion of the Ellendale field and drained the E9 area.

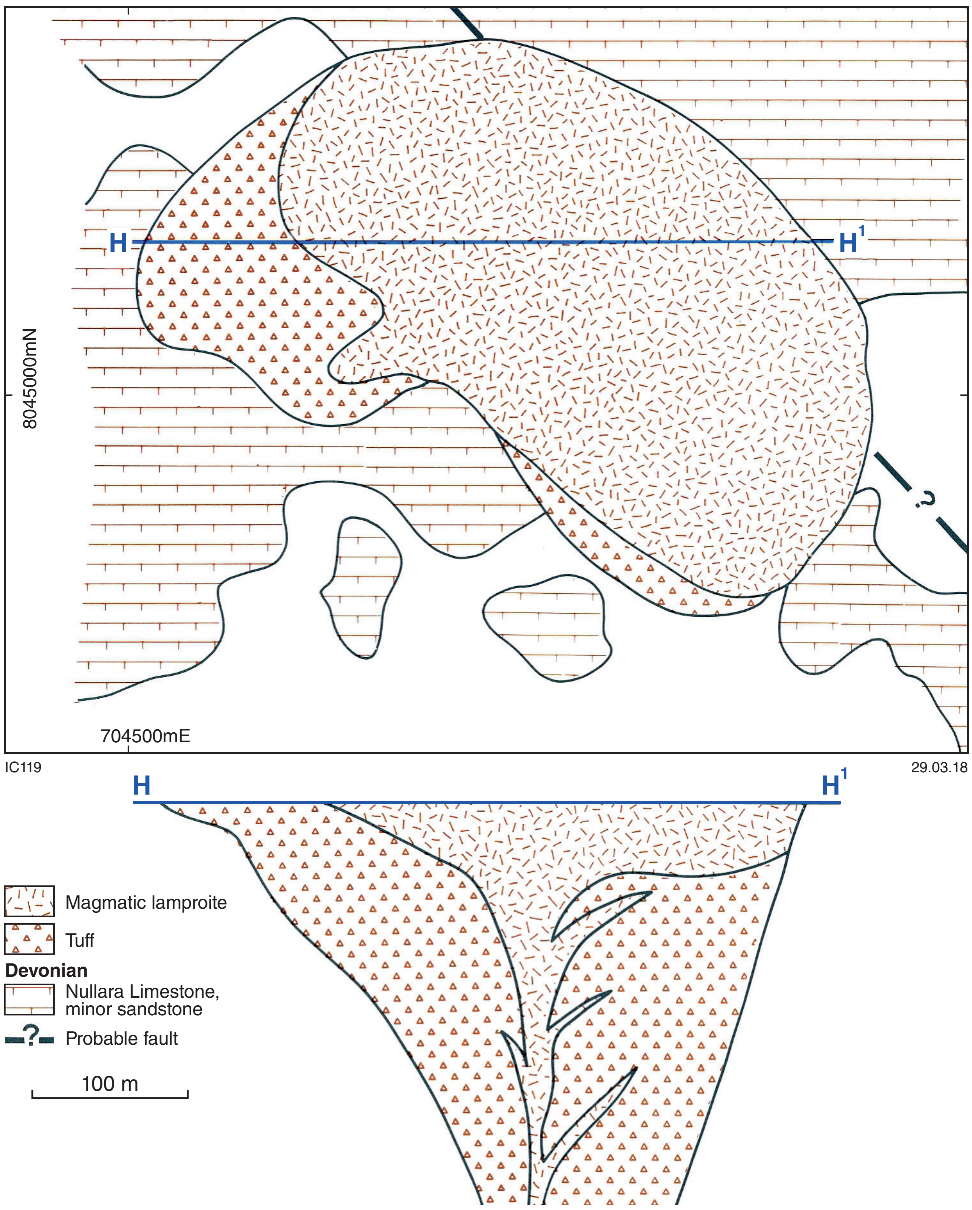

Figure 18. Surface geology and simplified cross-sections for E4S (after Boxer, 1991)

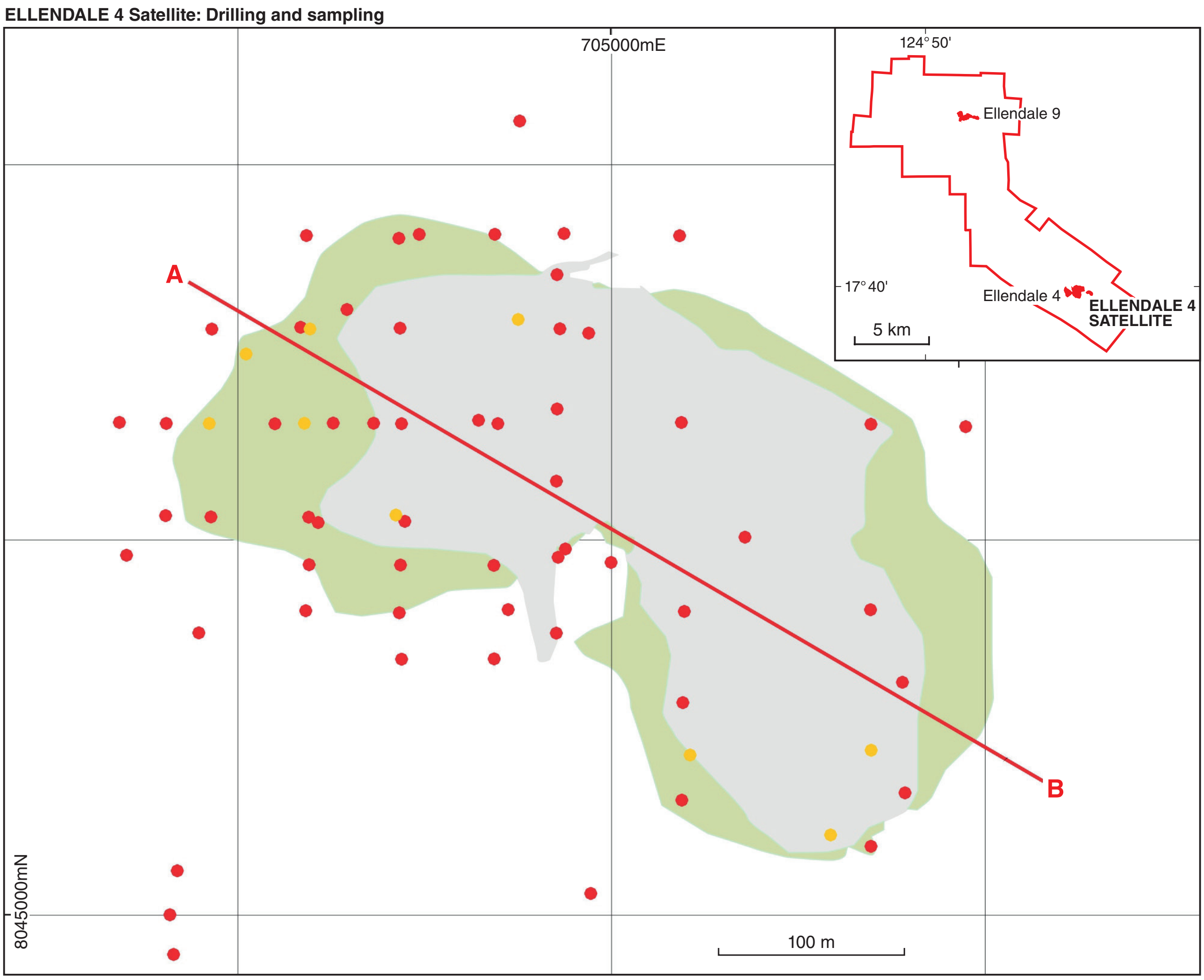

Figure 19. Drilling and sampling at E4S (after Telfer and McKenna, 2011)

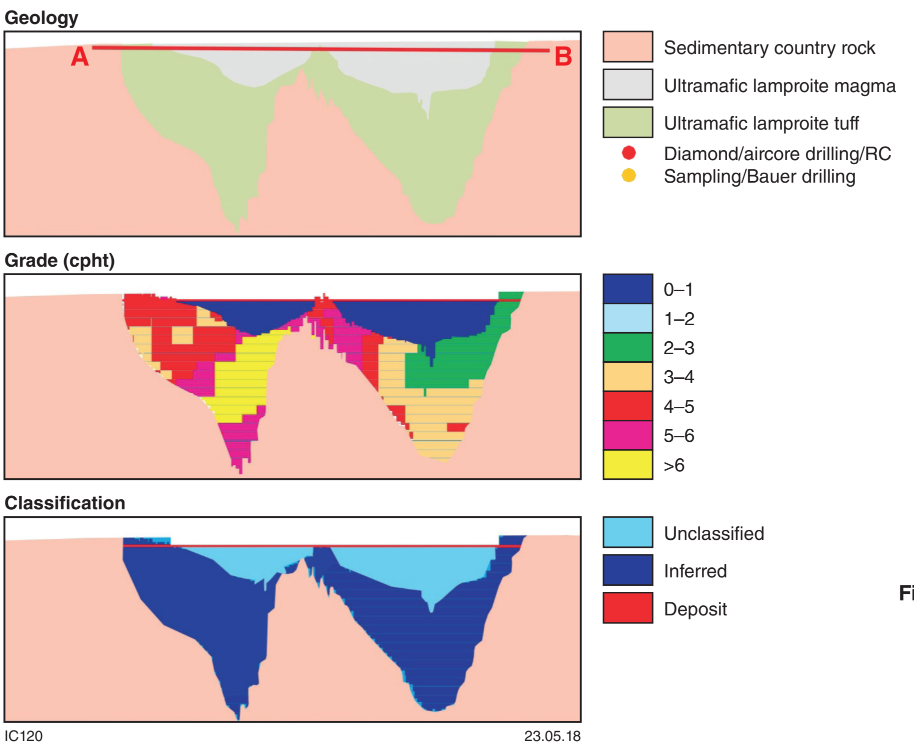

Figure 20. Cross-sections showing the geology, grade and resource classification for E4S. Cross-section A–B is shown on Figure 19 (after Telfer and McKenna, 2011)

Figure 21. Photo of a pit in E4S exposing the calcrete cap on the top of the pipe (photo by G Boxer)

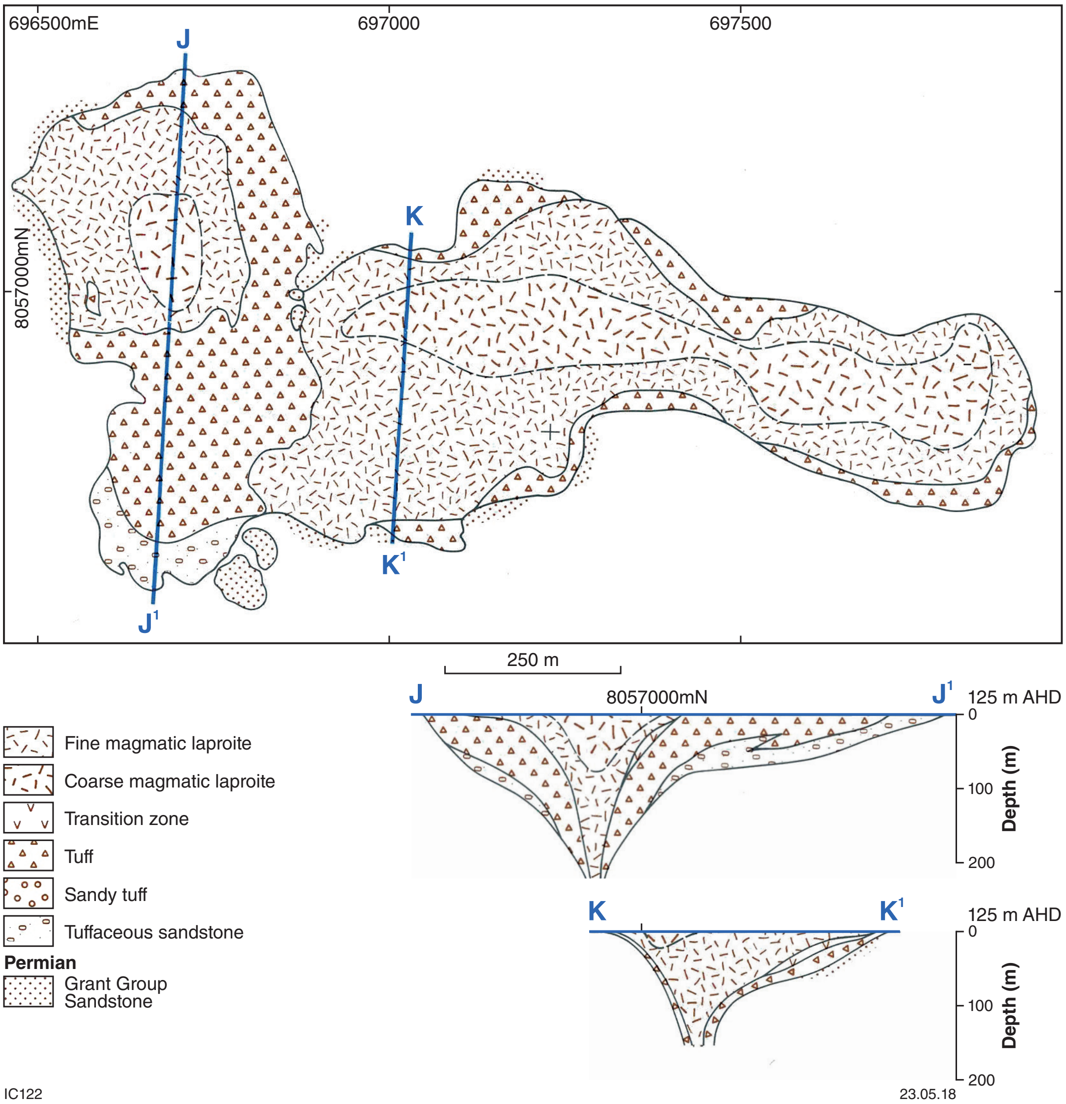

Figure 22. Pre-mining surface geology and simplified cross-sections for E9 (after Boxer, 1991)

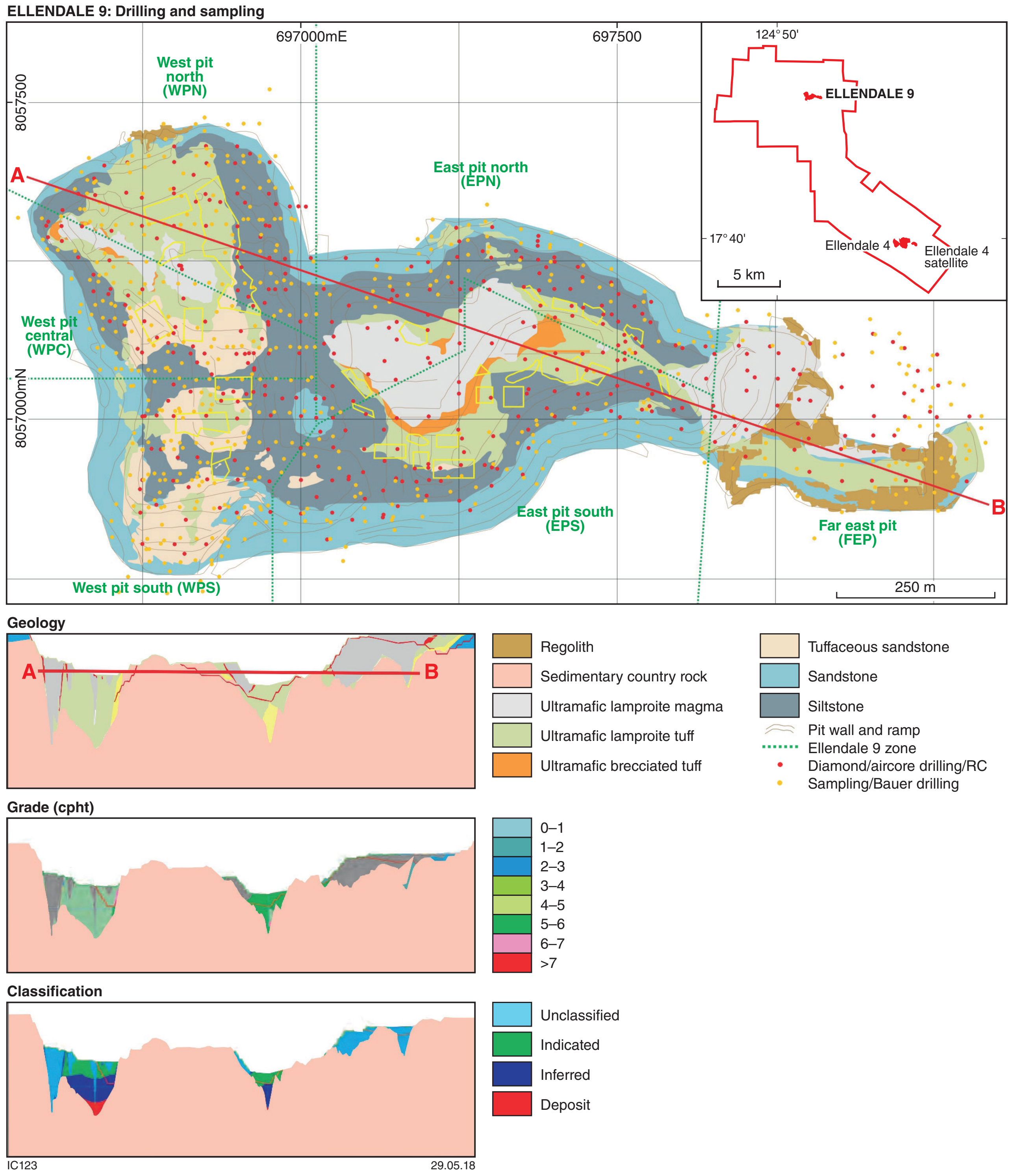

Figure 23. Drilling and sampling at E9, and cross-sections showing the geology, grade and resource classification for E9 (after Telfer and McKenna, 2011)

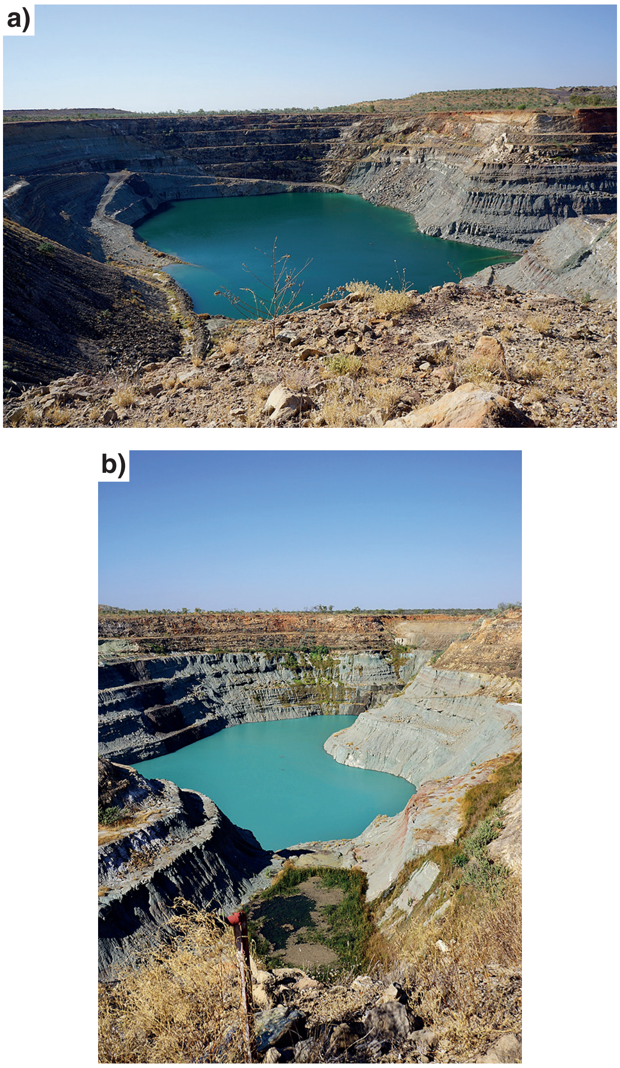

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Figure 24 **a) View to the north across the western lobe of E9 from the southern wall of the West pit south (photo by G Boxer); b) view to the east across the eastern lobe of E9 from the southern wall of the West pit south (photo by G Boxer)**

Terrace 5 continues to the west of the former mining lease boundary onto exploration and mining tenements originally held by Blina Diamonds NL. Most details on the internal geology of the paleochannel come from the excavation by Blina of two large bulk samples, termed Cut 1 and Cut 2, which were located 1.4 and 4.6 km west of the Ellendale mine lease boundary (Jones and Rockett, 2006).

The stratigraphy of the Terrace 5 channel is summarized below and typically comprises a basal gravel on sandstone bedrock covered by alluvial sandy clay, grey sand, and red pindan sand.

Pindan sand

The pindan sand is a dunal deposit comprising fine- to coarse-grained, rounded and frosted quartz grains, and characterized by its deep-red colour and moderate to high clay content. It varies in thickness from 2 to more than 15 m. The base is commonly marked by a horizon of moderately to well-developed in situ laterite. Clay content and grain size tends to increase towards the base.

Grey sand

Grey sand is present between the sand dunes. It is yellow-grey in colour and possibly associated with past or current ephemeral wetlands. It comprises fine- to coarse-grained frosted and polished quartz grains and a high clay content. A laterite horizon at the base commonly acts as a barrier to water penetration, causing such areas to remain wet for long periods.

Alluvial sandy clay

Alluvial sandy clay is the dominant sediment within the Terrace 5 channel stratigraphy and is partially lithified. This unit contains medium- to very coarse-grained quartz grains that are well rounded and polished, and commonly up to 3 mm in size. The proportion of quartz to clay is variable, but is typically 50:50. This unit has been termed ‘sandy clay’ in order to differentiate it from the overlying non-alluvial channel clayey-sand units.

The top of the sandy-clay unit is partially lateritized and contact with the overlying sand unit may be unclear. Below the laterite, the unit is strongly overprinted with iron staining, giving it a mottled yellow-orange-red colour, with iron staining decreasing with depth. Floating grit or pebble gravel horizons are present within the sandy-clay unit. A marker grit horizon, comprising transported laterite (5–15 mm) with minor small rounded quartz pebbles up to 20 mm in size, has been intersected in most drillholes and test pits throughout the Terrace 5 paleochannel. This horizon is commonly laterally discontinuous and varies in thickness from 50 to 200 mm. In both Cut 1 and Cut 2 the horizon included, in places, cobbles ranging up to 200 mm in diameter; however, all the test samples taken from coarser portions of the floating gravels were barren.

Basal gravel

The basal gravel comprises a mix of clast-supported and matrix-supported gravels. Clasts mostly range from 20 to 150 mm in diameter, with occasional larger clasts of mainly rounded quartzite and sandstone up to 400 mm in size. Clast types include yellow-white, subrounded fine- to medium-grained quartz sandstone, ferruginized fine- and medium-grained sandstone, quartz pebbles, and quartzite cobbles. The gravel matrix comprises transported laterite and sandy clay. The more clast-supported gravels have a coarse sand or transported laterite matrix, and the proportion of sandy clay in the matrix increases with the decrease in clast content (Fig. 25). Matrix-supported gravels commonly grade laterally and vertically into more clast-supported units.

Some gravel sequences, notably in Cut 2, comprise two horizons with variable amounts of sandy clay between the two layers. Bedrock highs with little gravel, and potholes in the channel base with gravel thicknesses up to 3 m, have been intersected. Gravel thicknesses vary considerably across Terrace 5 and in many areas the basal gravels have been scoured out. However, in almost all holes drilled or pits excavated into the Terrace 5 sequence, there is some basal gravel or grit horizon marking the base of the channel. Locally, especially where tributaries come in from the north, the sandy-clay sequence is missing and the pindan sand directly overlies the gravel sequence (Fig. 26).

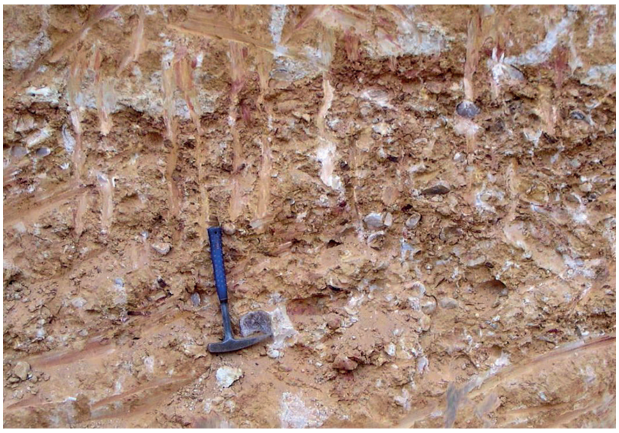

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Figure 25. Example of clast-supported gravels overlying bedrock comprising highly weathered fine- to medium-grained feldspathic quartz sandstone (photo by GMI Rockett)

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Figure 26. Gravel unit underlying pindan sand in the northern terraces and tributaries. The sandy-clay sequence is absent from these areas (photo by GMI Rockett)

Sandstone bedrock

Grant Group sandstones underlie most of the Terrace 5 paleochannel, with Poole Sandstone forming the bedrock under its western end, to the west of the former Ellendale mining lease. The Grant Group sandstones comprise mostly fine- to medium-grained quartz and feldspathic quartz sandstone, with less common horizons of fine-grained clayey sandstone or siltstone, and coarse pebbly (quartz and quartzite) clayey quartz sandstone (Fig. 27). The sandstones are commonly highly weathered immediately below the basal gravels and this causes some problems when defining the base of the channel, as highly weathered feldspathic sandstone has very similar physical characteristics to sandy clay in drill chips. Calcrete concretions are common in the weathered bedrock, especially when proximal to a lamproite pipe.

Test pitting

The Kimberley Diamond Company commenced exploration for alluvial diamonds in the Ellendale area in 1994. The paleochannel, which became known as Terrace 5 after pit 5 (BLBS005) where the first diamonds were discovered, has been traced for over 35 km and onto the former Ellendale mining lease M04/372. The work comprised delineation test pitting and bulk sampling using a backhoe or excavator as KDC tracked the alluvial channel upstream towards the mining lease.

Bauer drilling

Thick sequences of sand cover made test pitting using an excavator a slow exploration method due to the stringent environmental and safety controls requiring the avoidance of large surface disturbances. An aircore drill program, although quicker and with less surface disturbance, did not provide adequate control on gravel thickness and recovered limited material for indicator mineral sampling. In 2006, the use of a Bauer BG20 drillrig was successfully trialled (Rockett, 2007). A wide-diameter Bauer drilling program commenced on Terrace 5 upstream of Cut 1 and followed through to the process plant area adjacent to E9. The program aimed to define and map the headwaters of the Terrace 5 system. The Bauer BG20 rig drilled a 1 m-wide hole to a maximum depth of 50 m (Fig. 28). Accurate depth measurements were possible, thus providing good control on depth and thickness of gravel intersections as well as depth to bedrock.

The drill program covered a 30-km^2 section of the Terrace 5 headwaters with drillhole spacing at 250 × 40 m. The track-mounted BG20 rig moved along partially cleared tracks with little impact on the topsoil or grasses. The 1-m bucket provided sufficient gravel to sample for indicator minerals and diamond and the gravel clasts were not destroyed, thus allowing for changes in the downhole stratigraphy to be accurately mapped in 25-cm swathes. All drillholes were immediately backfilled on completion of logging, and only the gravel portion of the stratigraphy left on the surface for sampling.

During the five-month program, 2237 holes were drilled for 17 879 m, and the known extent of the main Terrace 5 channel was mapped for 7 km east of Cut 1. In addition, 15 new tributaries and terraces were identified in the upper reaches of the Terrace 5 catchment.

Channel interpretation

Each Bauer drillhole site was surveyed providing an accurate fix on easting, northing and collar reduced level (RL) or elevation. By combining surface RL data with downhole measurements to bedrock, the bedrock surface was contoured, and the position of subchannels and possible gravel horizons interpreted between the drill lines. Three previously unknown alluvial subsystems were identified and designated as the Ellendale 7, Ellendale 11, and Ellendale 12 alluvial areas. North–south cross-sections show the Terrace 5 alluvial system to be complex, with subparallel terraces at different relative levels. Three cross-sections described below illustrate the main features of the Terrace 5 paleochannel (Rockett, 2007).

Section '689750E'

Located directly to the east of Cut 1, this section shows the deepest part of the main Terrace 5 channel (MGA 689750E 8058000N). This steep-sided channel has thick clast-supported gravels, sometimes with double horizons. To the south, the base of the channel ramps upwards rapidly and disappears. Red dunal pindan sands cover the channel sequence in depths between three and ten metres. Alluvial sandy clay fills the thickest parts of the channel overlying clast- and matrix-supported gravels. In situ lateritization is present at the basal contact of the pindan sand and the underlying lithological unit, which is either sandy clay of the alluvial sequence or bedrock. Higher level terraces are present on the northern side of the channel and run subparallel to the main channel system. These gravels are dominated by transported laterite and tend to underlie the pindan sand without an intervening sandy-clay sequence. Sandstones of the Grant Group form the bedrock.

Section '690000E'

Approximately 400 m to the east, and 'upstream' from Cut 1, the Terrace 5 channel appears to branch into two equally deep channels with thick gravel sequences. Again, there are higher gravel terraces present to the north of the main channel system. The two channels are interpreted to remerge further upstream.

Section '692750E'

The main Terrace 5 channel passes between three lamproite pipes, about 3 km upstream from Cut 1, with Ellendale 13 to the north of the paleochannel, and Ellendale 12 plus Kimberley 46 to the south of the paleochannel. All three lamproite pipes were intruded into sandstones of the Grant Group. Grey alluvial sands, reflecting current-day drainage and ephemeral wetland areas, crosscut overlying pindan dunes. Sandy clay forms the dominant channel fill, with in situ lateritization present at the upper contact with the overlying pindan sand. Gravel horizons are thick (about 0.5 m) and clast supported. Tributaries, which feed into the main channel downstream, are present to the north of the paleochannel and crosscut the Ellendale 13 pipe.

Ellendale 13 is a known source of some diamonds in the Terrace 5 alluvials and contributes to the high concentrations of chromites in the system. Kimberley 46, a small tuffaceous pipe 200 m to the west of Ellendale 12, was discovered by Blina's Bauer drill program. Ellendale 12, a mainly magmatic lamproite, contains scarce diamonds and is not considered a significant contributor of diamonds into the Terrace 5 system.

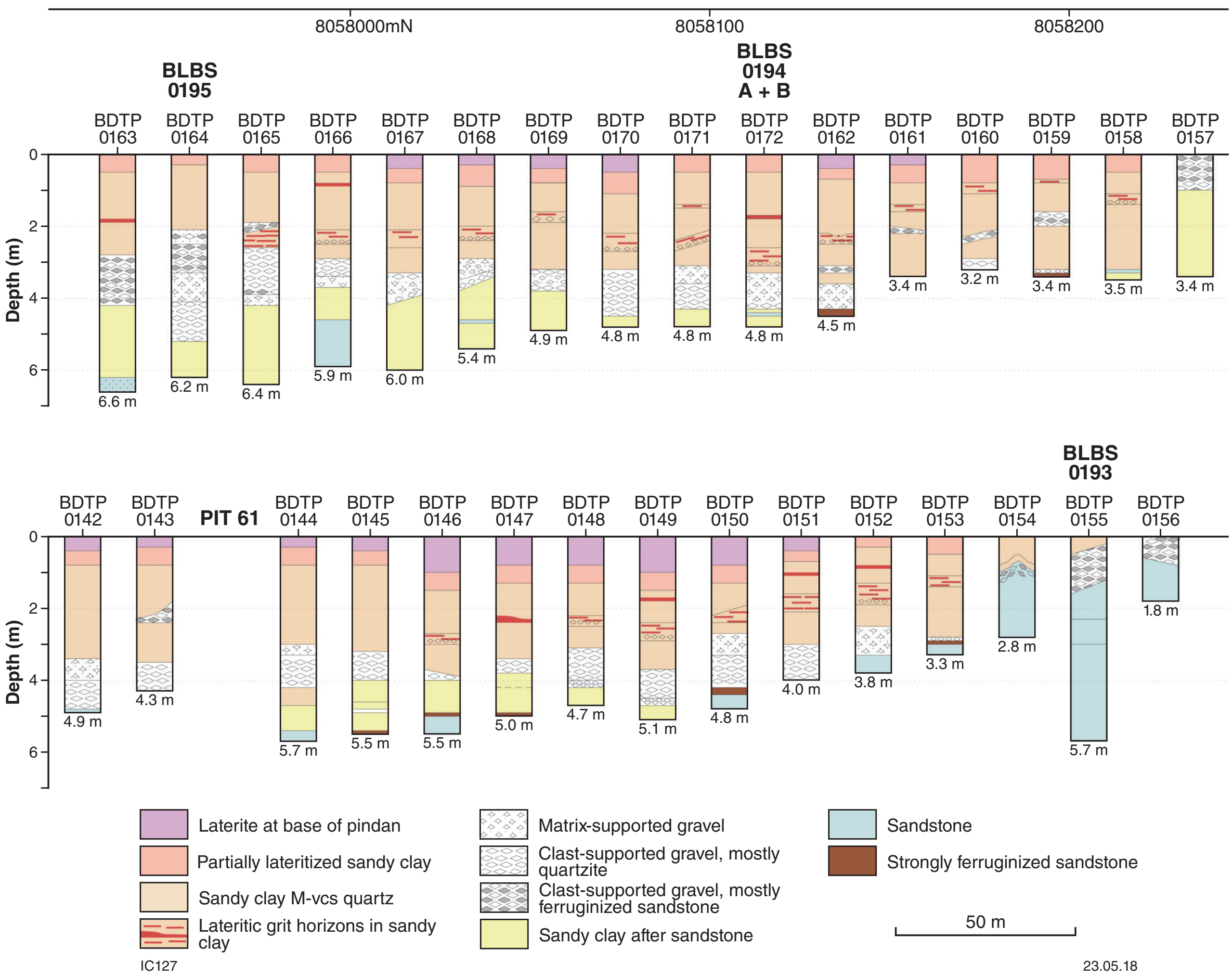

Figure 27a. Geological logs of pitting along Cut 1 (after Jones and Rockett, 2006)

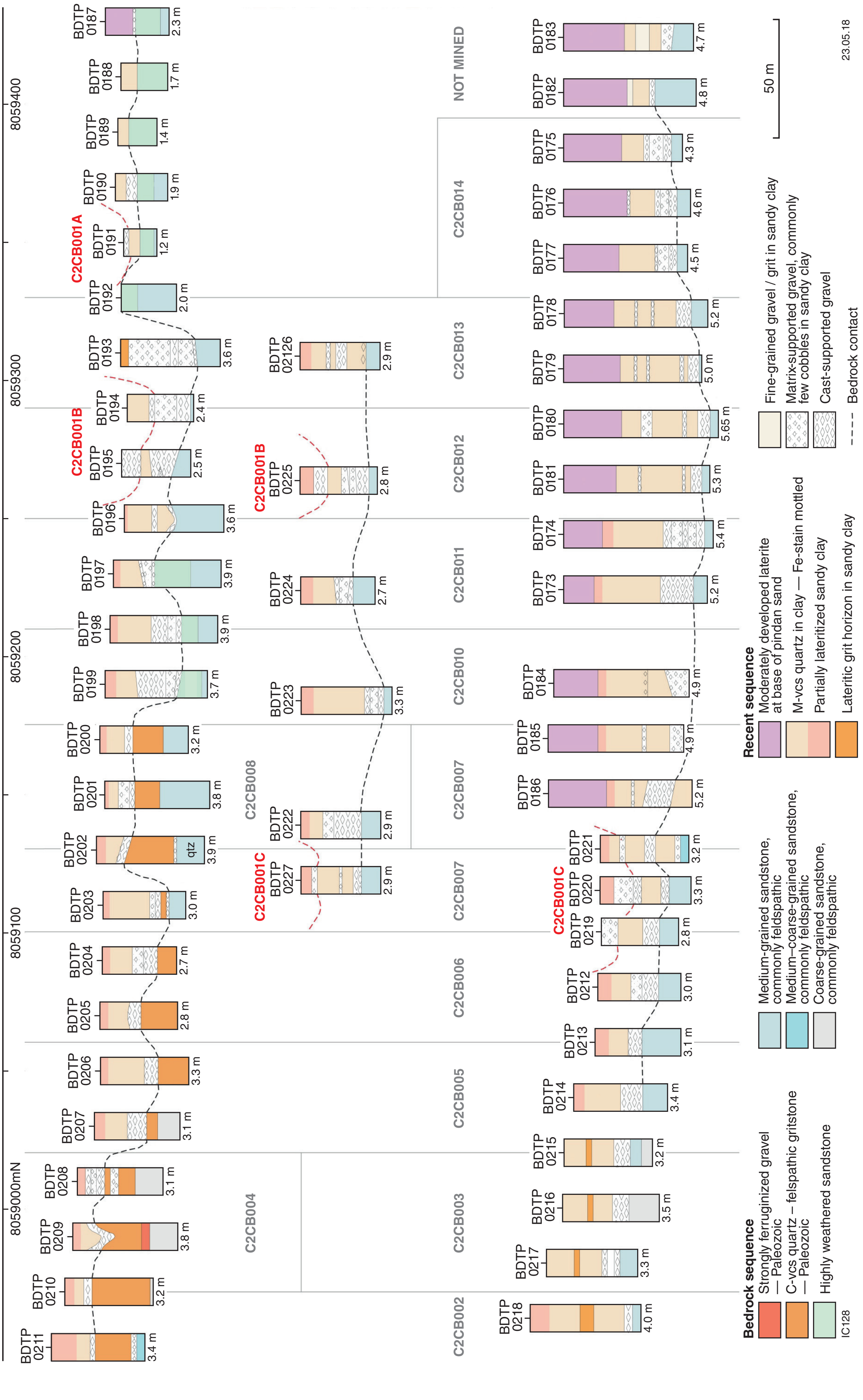

Figure 27b. Geological logs of pitting along Cut 2 (after Jones and Rockett, 2006)

Figure 28. BG20 drilling on Terrace 5 (photo by GMI Rockett)

Geochemical sampling

Grab samples of Bauer drill spoil were taken from the base of the overburden and the bedrock at the end of hole. A total of 1907 overburden samples and 1911 end-of-hole samples were analysed for eight lamproitic elements (Ba, Ce, Cr, La Nb, Nd, Ni, and Y) with the aim of detecting additional bedrock lamproite occurrences.

Indicator mineral sampling

A selection of gravels recovered from the drilling was sampled for indicator minerals. The gravels chosen represented either variations within the main channel or tributaries entering the system. Each 40-kg sample comprised the –5 mm fraction sieved from the gravels and was sent for processing for indicator minerals and diamond. A total of 120 samples were taken and the results helped to build a picture of which tributaries delivered lamproitic indicator minerals, and potentially diamond as well, into the system.

Exploration pitting and bulk sampling

In follow up to the Bauer drill program, test pits were excavated at sites where the depth to bedrock did not exceed 7 m. The purpose was to verify the lithological logging of the Bauer drillholes, especially in places where the gravel was interpreted as matrix supported or the stratigraphy appeared more complex than normal. Bulk sampling on Terrace 5 has focused on testing subchannels and tributaries flowing into the alluvial system identified during the Bauer drill program. Eighteen samples were taken from 11 pits with 2772 t hauled to the Blina dense media separation (DMS) plant during 2006 (Table 1).

Trial mining in the form of two large pits (Cut 1 and Cut 2) excavated across the alluvial channel was undertaken in 2005 (Jones and Rockett, 2006). Although these lie off the Ellendale mining lease, they are indicative of the potential of the Terrace 5 alluvial system. The trial mining aimed to recover about 2000 ct of diamonds for valuation purposes as the preliminary step towards determining the economic viability of the Terrace 5 alluvial system.

All gravel samples from Cut 1 and Cut 2 were processed through Blina's 50-tonne per hour (tph) production DMS processing plant, and final recovery was undertaken by KDC via a twin-stage Flow Sort X-ray machine and hand-sorting of the final product. The Blina production plant scalped off 100 mm material before scrubbing and rejection of +16 mm as oversize and –1.5 mm as undersize. Results from this DMS are therefore from the –16 + 1.5 mm fraction (Table 2).

Diamond valuation

The diamonds recovered from the two trial-mining pits were cleaned and sized at KDC's recovery facility located near the E9 plant. A parcel of 1497.58 ct was submitted for valuation in April 2006 (Table 3; Fig. 29). The 1497.58 ct represented 3653 stones, giving an average stone size of 0.41cts.

Exploration potential

The 2006 Bauer drill program proved to be very successful and demonstrated that the internal stratigraphy of the Terrace 5 alluvial system is complex, with large variations in gravel thickness and diamond grades. Further delineation work is required before the mining potential of this system can be defined.

The portion of the channel system from the former mining lease boundary upstream from Cut 1 to Ellendale 12 (E12) is reasonably well defined by the Bauer drill data and supporting exploration pits, trenches and bulk-sample results. Using an estimate of 200 ha, and 0.5 m average gravel thickness, this equates to approximately 1.2 Mm^3 or about 2 Mt. Non-ground disturbing techniques such as ground-probing radar or ground EM may assist in defining the deeper portions of the channel system and the internal stratigraphy. These techniques can be ground tested against the north–south profiles that have been established in reasonable detail from the Bauer drill program. Radar trials in similar environments have proven very successful in delineating alluvial channels. Recent results from radar imaging by POZ Minerals Limited (2017) have shown this technique to be very successful in this area.

E12 Alluvials

The 2006 Bauer drill program identified a wide shallow channel to the south of E12. This alluvial system begins as a number of smaller tributaries before coalescing into a large channel with clast-supported gravels mostly concentrated along the north and south banks. Only minor gravels are present in the central portion of this channel, presumably due to the original basal gravels being scoured as the old river eroded deeper into basement rocks. The E12 Alluvials channel is interpreted to intersect the main Terrace 5 channel about 300 m downstream from E12.

Geology

The stratigraphy of the E12 Alluvials is similar to the main Terrace 5 paleochannel; however, the clast rock types of the basal gravels are significantly different. The gravels are both matrix and clast supported. Commonly, the basal 100–200 mm is clast supported, grading upwards to

Table 1. Summary of Terrace 5 bulk-sample results

Sample number	*Tonnes processed*	*Total carats*	*Number of diamonds*	*Average size*[(a)] *(ct)*	*Grade (cpht)*	*Largest diamond (ct) (+3.35 mm)*
Northern tributaries						
BLBS135	64.00	0	0	–	barren	–
BLBS136	170.25	0.030	1	0.03	0.02	–
BLBS137	284.40	0.605	2	0.30	0.21	–
BLBS138	171.70	0.280	2	0.14	0.16	–
BLBS141A	315.00	2.435	10	0.24	0.77	1.77
BLBS141B	90.95	0.405	13	0.03	0.45	–
Southern tributaries						
BLBS143A	143.95	0.690	9	0.08	0.48	–
BLBS143B	216.50	0	0	–	barren	–
BLBS143C	30.20	0.190	1	0.19	0.63	–
E11 tributaries						
BLBS139A	57.55	0.255	1	0.26	0.44	–
BLBS139B	93.25	0	0	–	barren	–
E12 Alluvials						
BLBS140A	105.20	0.100	3	0.03	0.10	0.07
BLBS140B	131.90	6.040	6	1.01	4.58	3.75
BLBS140C	22.90	2.490	5	0.50	10.87	0.95
BLBS170	256.65	16.195	38	0.43	6.31	2.83
BLBS173A	55.00	0.135	1	0.14	0.25	–
BLBS173B	315.85	28.490	62	0.46	9.02	4.10
Main Terrace 5 channel						
BLBS142	245.25	1.445	12	0.12	0.59	0.43

NOTE: (a) Diamonds recovered are from –14 +1.2 mm size fraction and weights are pre-cleaning
SOURCE: Rockett (2007)

Table 2. Summary of Cut 1 + Cut 2 results for the Terrace 5 project

Bulk-sample site	*Tonnes (t)*	*Size distribution (mm)*[(a)]		*Number of diamonds*	*Total carats*	*Average size (ct)*	*Grade (cpht)*	*Largest diamond (ct)*
		+3.35	*–3.35*					
Cut 1	40 445	676	1 698	2 374	959.25	0.40	2.37	5.92
Cut 2	31 605	336	757	1 093	472.34	0.43	1.49	7.00
Total	**72 050**	**1 012**	**2 455**	**3 467**	**1 431.59**	**0.41**	**1.99**	**7.00**

NOTE: (a) Diamonds recovered in the –16 + 1.5 mm size fraction and weights are pre-cleaning
SOURCE: Jones and Rockett (2006)

matrix-supported gravel. The matrix-supported portion is predominantly pebble gravels with 20–50 mm clasts, and a matrix of transported laterite and sandy clay. The matrix-supported gravels are difficult to identify in trench and pit walls due to their high clay content (Fig. 30). Clast types include white medium-grained sandstone, ferruginized sandstone, and quartz pebbles.

The clast-supported gravels have 30–150 mm clasts, with occasional large boulders up to 400 mm. Clast types include quartzite cobbles, 'cooked' sandstone (hard glassy sandstone with a white weathered rim), ferruginized sandstones, both pale and dark-grey chalcedony, and quartz pebbles in a transported laterite plus sandy-clay matrix. The subrounded clasts of 'cooked' sandstone and the presence of chalcedony clasts are unusual and have not been noted in gravels from the main Terrace 5 channel. Most gravel types from the E12 Alluvials area, and the overlying sandy-clay unit, are overprinted by weak to moderately developed in situ laterite. The gravel horizons are highly variable, with undulating upper and lower contacts grading laterally from matrix supported to clast supported, and vary in thickness from 0.1 to over 2 m.

Table 3. Terrace 5 diamond valuation

Diamond size	*Price per carat (US$)*	*Weight (ct)*	*Value (US$)*
8ct	3 187	8.43	26 864
7ct	658	6.86	4 516
6ct	2 423	5.9	14 298
5ct	–	–	–
4ct	2 520	20.9	52 671
3ct	658	78.11	51 435
8gr	503	156.93	78 877
6gr	287	111.47	31 976
5gr	289	70.85	20 482
4gr	154	155	23 828
3gr	90	174.42	15 695
+11	67	348.32	23 294
+9	62	195.83	12 156
+7	45	88.1	3 970
+5	38	68.03	2 562
-5	30	8.43	253
Total	**242**	**1 497.58**	**362 879**

SOURCE: Blina Diamonds NL exploration data

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Figure 29. Diamonds recovered from Terrace 5 sampling (photo by GMI Rockett)

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Figure 30. Typical gravel sequence from the E12 Alluvials. Thickness varies from 0.3 to 0.8 m (photo by GMI Rockett)

Channel interpretation

Gravel distribution in the E12 Alluvials paleochannel is complex. Topographic reconstruction from Bauer drillhole data combined with test pitting suggests a relatively broad valley with a series of meandering braided subchannels with up to 2 m-thick elongated gravel bars marking bends in the channel. The diamond grades appear influenced by the proximity of sample sites to these bends. Cross-sections drawn from the Bauer drill data show the channel to be 300–350 m wide on the western downstream end, with steep sides. Gravels are mostly restricted to the southern and northern sides of the channel. The deeper, central portion of the channel has very little basal gravel. Further work will be required to determine whether there is more than one channel, or if this is a broad valley that has been partially scoured and the gravels reworked downstream. The approximate locations of the bulk-sample pits (BLBS) with respect to the channel system are shown on Figure 31.

Exploration pitting and bulk sampling

Initial bulk samples collected from the E12 Alluvials area produced diamond grades and average stone sizes significantly higher than recorded elsewhere in the Terrace 5 system. In addition to containing larger diamonds, the diamond suite included those of distinctly different morphology and colour from that previously seen in the Ellendale area. Due to the occurrence of these distinct diamonds proximal to E12, KDC conducted a bulk-sampling and wide-diameter (2.5 m) Bauer drilling program over the E12 lamproite pipe. This bulk-sample program showed that the E12 lamproite tested is almost barren and not the source of the diamonds in the nearby alluvial system (Rockett and Chambers, 2009).

It should be noted that the lamproite exposed at surface represents the last phase of volcanism, with typically very low-grade magmatic lamproite, but does not preclude the eruption of diamondiferous tuffs earlier in the volcanic history of the pipe. This possible earlier tuff phase would have formed a tuff ring around the vent and may have been the source of these unusual diamonds. No exploration targeting this possible tuff ring at E12 has been carried out to date.

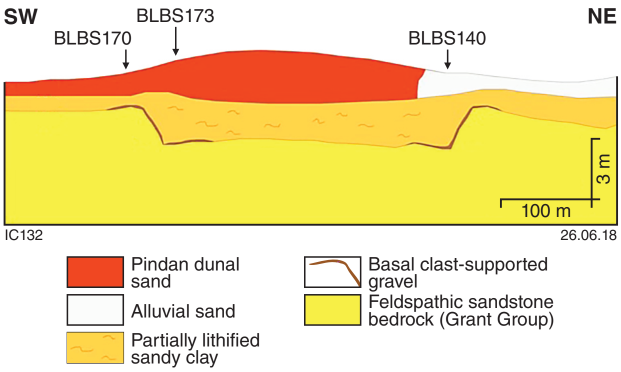

Figure 31. Cross-section through the E12 Alluvials channel, with the midpoint at MGA 692880E 8056885N (after Rockett, 2007)

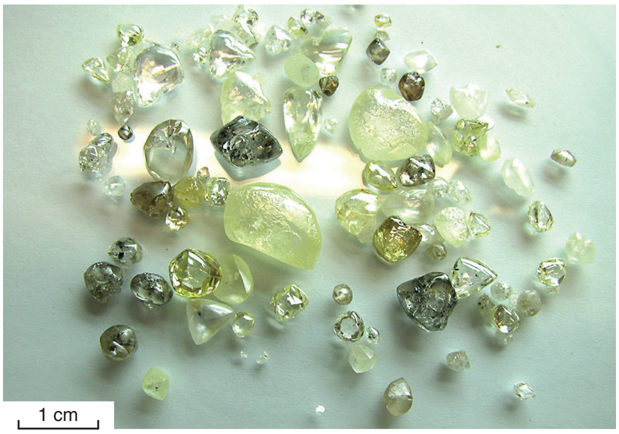

Figure 32. Diamonds recovered from the E12 Alluvials area, including a 6.03 ct pearly yellow diamond (photo by GMI Rockett)

Extensive pitting and trenching traced the alluvial channel over a strike length of 1.2 km, including 500 m upstream from the E12 lamproite pipe, adding further support to the theory that diamonds may have entered the alluvial system from an, as yet, unidentified source. This exploration returned encouraging results including:

- the highest grade and average diamond stone size recorded from a Terrace 5 bulk sample. BLBS216 was a trench sample of 82 t excavated across a portion of the alluvial channel and returned a grade of 15.85 cpht with an average stone size of 1.08 ct. The largest stone recovered was a 6.03 ct pearly yellow diamond (Fig. 32)
- the diamond population has a higher average stone size and a higher proportion of 'fancy yellows' than the main Terrace 5 system
- discovery of a 2.71 ct green diamond, plus two smaller stones with green colouration — these were the first green diamonds reported from the Ellendale field (Fig. 33)
- the alluvial channel, carrying gravels with promising grades and average stone sizes above 0.4 ct/stone, was traced as far as 500 m upstream from the site of the green diamond discovery.

Table 4 lists the E12 Alluvials bulk-sampling results.

Figure 33. Diamonds recovered from the E12 Alluvials area, including a 2.71 ct green diamond (photo by GMI Rockett)

Trial mining

A low-impact mining operation was undertaken in 2007 (Rockett, 2008), with two trial pits excavated in the E12 Alluvials area (Fig. 34). The first pit (E12-LIMO-01) was sited where the green diamond was recovered, on the northern edge of the channel, southwest of E12. The second pit (E12-LIMO-02) was situated on the southern side of the channel, straddling the BLBS216 trench. A total of 5770 t was excavated from the first pit (E12-LIMO-01) and hauled to Blina's DMS plant for processing. The second pit (E12-LIMO-02) provided a further 1680 t.

The recovered grades were lower than anticipated and probably reflect significant dilution by waste material due to the difficulty of mining a gravel horizon that pinches and swells in thickness. Table 5 summarizes the results from these pits.

Figure 34. E12 Alluvials trial mining pit E12-LIMO-01 (photo by GMI Rockett)

Table 4. E12 Alluvials exploration bulk-sample results

Sample number	Year	Tonnes processed	Diamond size distribution (mm)[a] +3.35	Diamond size distribution (mm)[a] –3.35	Number of diamonds	Total carats	Average size (ct)	Grade (cpht)	Largest diamond (ct)
BLBS140B	2006	132	2	4	6	6.040	1.01	4.58	3.75
BLBS140C	2006	23	3	2	5	2.490	0.50	10.87	0.95
BLBS170	2006	256.7	11	27	38	16.20	0.43	6.31	2.83
BLBS173	2006	315.9	17	45	62	28.49	0.46	9.02	4.10
BLBS209	2007	71	2	7	9	2.44	0.27	3.46	0.70
BLBS210A	2007	58	0	0	0	0.00	–	barren	–
BLBS210B	2007	54	0	0	0	0.00	–	barren	–
BLBS210C	2007	65	1	1	2	1.94	0.97	2.98	1.81
BLBS210D	2007	88	6	20	26	5.26	0.20	5.97	0.66
BLBS211A	2007	73	1	0	1	0.35	0.35	0.48	0.35
BLBS211B	2007	83	2	1	3	1.71	0.57	2.06	0.69
BLBS212	2007	115	1	6	7	1.57	0.22	1.37	0.46
BLBS213A	2007	32	0	9	9	0.24	0.03	0.76	n/a
BLBS213B	2007	107	2	2	4	4.69	1.17	4.39	2.67
BLBS214	2007	54.2	1	3	4	2.38	0.60	4.40	1.64
BLBS215	2007	66	3	3	6	4.77	0.80	7.23	2.72
BLBS216	2007	81.9	7	5	12	12.98	1.08	15.85	6.03
BLBS217	2007	58	0	3	3	0.64	0.21	1.10	n/a
BLBS218	2007	100.3	3	2	5	3.70	0.74	3.69	2.14
BLBS219	2007	73.9	2	2	4	2.21	0.55	2.99	1.08
BLBS220	2007	97.6	3	7	10	4.27	0.43	4.38	2.06
BLBS228	2007	50	3	0	3	1.79	0.60	2.46	0.62
BLBS229	2007	110	3	12	15	3.21	0.21	2.91	0.64
BLBS230	2007	38	0	2	2	0.18	0.09	0.47	n/a
BLBS231	2007	51	0	1	1	0.38	0.38	0.75	n/a
BLBS232	2007	40.1	3	2	5	2.51	0.50	6.26	1.01
BLBS233A	2007	86	0	1	1	0.03	0.03	0.03	0.03
BLBS233B	2007	43	0	2	2	0.02	0.01	0.05	n/a
BLBS233C	2007	110	3	5	8	2.52	0.32	1.48	0.64
BLBS234	2007	50	4	3	7	3.02	0.43	6.04	0.80
BLBS235	2007	136	3	9	12	3.65	0.30	2.68	0.84
BLBS236	2007	30	1	0	1	0.95	0.95	1.26	0.95
BLBS237	2007	60	0	2	2	0.21	0.11	0.35	n/a
BLBS238	2007	216	4	5	9	4.97	0.55	2.30	1.23
BLBS239	2007	403	20	31	51	21.94	0.43	4.83	3.00
BLBS240	2007	143	7	10	17	8.22	0.48	5.75	1.53
BLBS241	2007	182	3	5	8	2.35	0.29	1.07	0.84
BLBS254	2007	144	3	6	9	6.03	0.67	4.19	2.95
Total		**3897**	**124**	**245**	**369**	**164**	**0.45**	**4.22**	**6.03**

NOTE: (a) Diamonds recovered from the –14 +1 mm size fraction
SOURCE: Rockett (2008)

Table 5. E12 Alluvials LIMO pit samples

Sample number	Tonnes processed	Total carats[a]	Grade (cpht)	Average size[b] (ct)	Largest diamond[c] (ct)
E12-LIMO-01	5762.64	198.81	3.51	0.50	7.24
E12-LIMO-02	1678.5	68.62	4.09	0.60	4.46
Total	**7441.14**	**267.43**	**3.59**	**0.53**	**7.24**

NOTES: (a) Cleaned diamond weight
(b) Diamonds recovered from the –14 +1.5 mm size fraction
(c) +3.35 mm

SOURCE: Rockett (2008)

Diamond valuation

The diamonds from the trial mining samples, plus stones recovered from the project's exploration samples, were submitted for valuation in February 2008 (Fig. 35). This parcel of 428.3 ct was valued at US$453/ct. Table 6 summarizes this valuation.

Figure 35. A 152.43 ct parcel of +13 to +23 DTC (Diamond Trading Company round-hole sieve series) stones recovered from the E12 Alluvials trial mining (photo by GMI Rockett)

Table 6. E12 Alluvials diamond valuation

Diamond size	*Price per carat (US$)*	*Weight (ct)*	*Total value (US$)*
+5ct	1 792	24.48	43 880
3–4ct	912	44.78	40 832
8gr	1 076	47.19	50 765
4–6gr	338	102.54	34 689
–3gr	114	209.31	23 885
	453	428.30	194 050

NOTE: gr is an abbreviation for grainer and refers to the sieve size. 4–6 gr is equivalent to 1 – 1.5 ct and thus a 4-grainer diamond is equivalent to a 1-ct diamond
SOURCE: Blina Diamonds NL exploration data

Resource potential

A mining proposal was submitted to the Department of Mines and Petroleum by Blina Diamonds NL in July 2008 covering an area 1.2 km long by 0.3 km wide over the E12 Alluvials project. This area, with an estimated average gravel thickness of 0.4 m, equates to 144 000 m^3 or 244 800 t with a probable recoverable grade of 3.5 cpht. Although approval was received in March 2009, the mining program did not commence (Rockett, 2009).

Upstream of the area covered by the E12 Alluvials mining approval, there is potential for the gravels to continue along this channel. There is also potential for diamondiferous gravels within the main Terrace 5 channel to the north; however, the thickness of overburden is much greater than that overlying the E12 Alluvials channel. Although there are 85 aircore drillholes and 176 Bauer drillholes in this area, no test pits or bulk samples have been undertaken. Indicator mineral samples from gravels intersected in Bauer holes returned kimberlite chromites indicating that the gravels have the potential to carry diamond.

E4 A-channel

The E4 A-channel project area is located at the southeastern end of the Ellendale field and targeted alluvial diamonds shed from the E4 lamproite pipe (Fig. 36). E4 lies close to a major drainage divide that sheds diamonds northwards into the E4 A-channel project area, and southwest into the E4 J-channel project area. Historical exploration in the area was undertaken by Century Metals and Mining NL during the period August–November 1986. As their exploration program moved downstream from Mount Percy (a leucite lamproite pipe) towards the E4 A-channel project area, the trench samples returned positive results for diamond indicator minerals, with 20 macrodiamonds recovered ranging in size from 0.0074 to 0.0105 ct.

The E4 A-channel project area was initially recognized by a distinct niobium geochemical anomaly identified from a regional termite-mound sampling program (Wright and Rockett, 2005). It showed similar characteristics to the Nb anomaly that led to the discovery of the alluvial systems north of E9. A stream-sediment sample collected from the current drainage during 2006 proved to be extremely diamondiferous, with seven macrodiamonds (+0.4 mm) weighing 0.086 ct recovered from 37.6 kg. A trenching and bulk-sampling program to test for a paleochannel in the area commenced in May 2007 (Rockett, 2008).

Geology

The E4 A-channel project area lies to the north of E4 within a depression on the underlying Nullara Formation that has been filled with recent sediments. The E4 A-channel alluvial deposits are primarily controlled by faults and fractures in the Nullara Formation that have enhanced the formation of a paleokarst terrain that controls the distribution of gravel. The E4 A-channel alluvial system comprises a series of fluvial gravels deposited over this karstic limestone terrain.

An extensive pitting and trenching program in the project area identified two possible channels with gravel thicknesses of up to 4 m. The limestone basement is extremely irregular, providing potential for potholes and other alluvial trap sites.

Western gravel sequence

This gravel sequence comprises clayey sands over calcretized sandy clay, with underlying highly calcretized lateritic gravel. Calcretization increases with depth and commonly forms a solid layer at about 2 m. Underlying this horizon is a sandy-clay matrix-supported lateritic gravel that fills pockets between large limestone slabs and includes high-density clasts such as iron concretions that are located throughout the sequence (Fig. 37). The limestone slabs are derived from the bedrock and may have eroded from surrounding topographic highs and slid into the channel during deposition. This sequence is the main paleochannel through the project area, with bedrock forming steep sides to the channel. Initial test pitting did not reach solid bedrock. BLBS201, BLBS203 and BLBS205 are typical of this gravel sequence (Fig. 38).

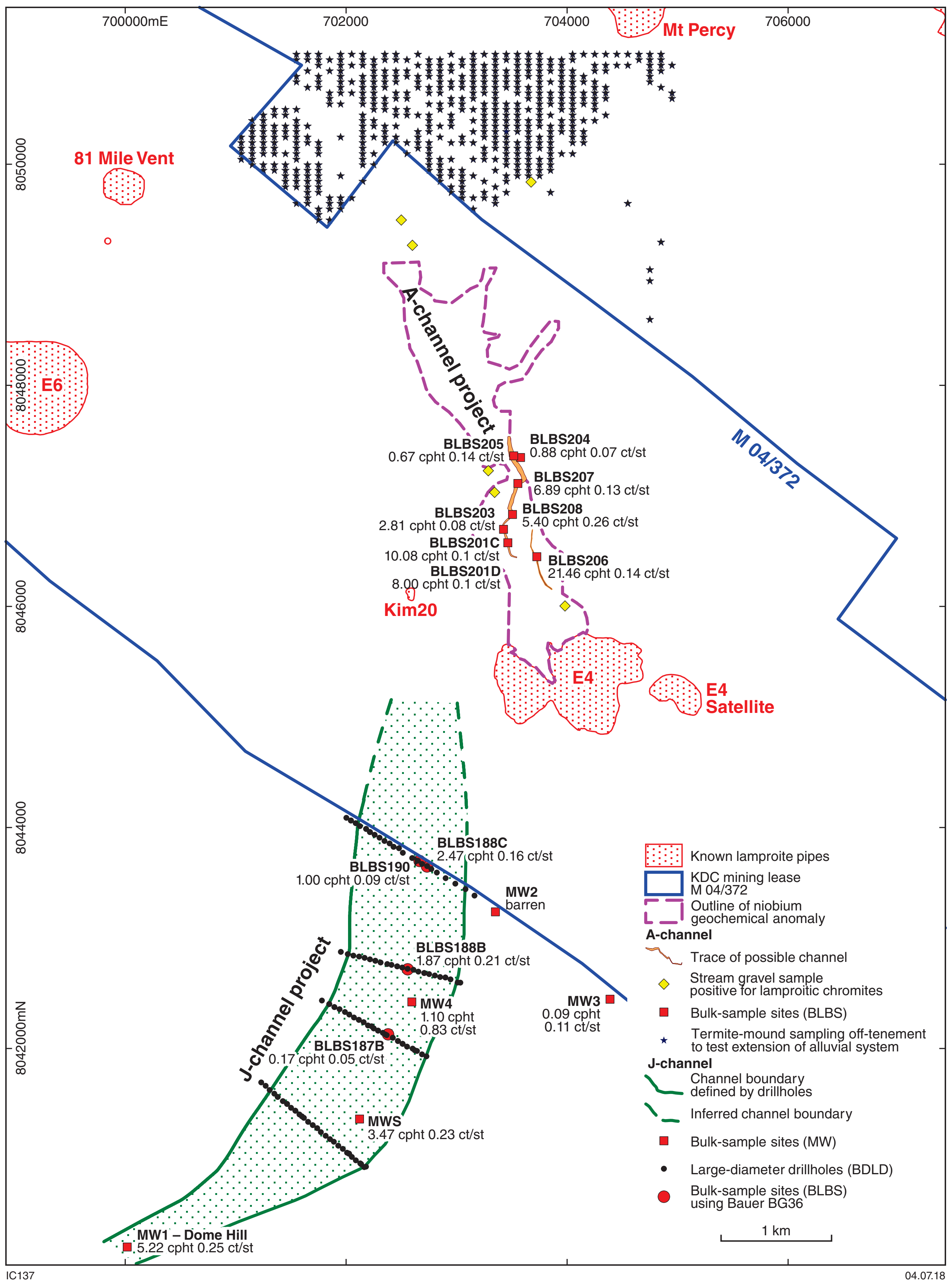

Figure 36. Location of the A-channel and J-channel projects relative to E4. Some of the exploration results are also shown

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Figure 37. Basal matrix-supported gravel from BLBS201D (photo by M Hawke)

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Figure 38. BLBS201 pit wall, showing the location of the four samples (photo by M Hawke)

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Figure 39. Close-up of lateritic grit that is typical of BLBS206 (photo by M Hawke)

Eastern gravel sequence

On the eastern side of the project area, a thin small- to medium-pebble gravel that is composed of mostly laterite has formed in paleokarst depressions. This is commonly accompanied by minor clasts of calcretized gravels that may have formed in situ. The paleochannel system hosting this gravel is narrow at less than 2 m and erratic. The gravel sequence is generally hosted in a yellow-brown sandy-clay matrix, but is overlain in places by pindan sand which suggests that it may also be a lag gravel. This lateritic gravel dominates the eastern portion of the project area, and may possibly merge or crosscut the western channel to the north.

BLBS206, BLBS207 and BLBS208 were typical of the eastern gravel type. BLBS206 consisted of a matrix- to clast-supported gravel with fragments of calcretized gravel generally cemented onto limestone fragments. Angular limestone cobbles were scattered throughout and held in a matrix of sandy clay, transported laterite and rounded iron sandstone (Fig. 39).

Over most of the E4 A-channel area, reddish-brown to brown clayey sands cover the gravel sequences. Upstream towards E4, pindan sand predominates as the overlying sediment, filling the gaps between the Nullara Formation bedrock. The headwaters of these paleocreek systems may have been eroded out in this area, or missed during the test-pitting program. The eastern gravel sequence appears to merge with the current-day creek to the south of the project area.

Bedrock

The bedrock to the gravels in this area is the limestone backreef deposits of the Devonian Nullara Formation, and is predominately an oolitic limestone composed of oolites with a diameter of 0.5 – 2.0 mm set in a crystalline carbonate matrix.

Calcrete cap

A massive, semi-laminated horizon of calcrete that overprints the clayey sand covers the western steep-sided channel. This varies in thickness from 0.2 to 0.8 m and was thickest in bulk-sample pit BLBS205. Commonly this horizon is underlain by sandy clay with varying amounts of transported laterite, or a matrix- to clast-supported lateritic gravel. Large boulders and floaters of limestone can also be found throughout. The calcrete cap occasionally overlies the limestone bedrock.

Current-day creek morphology

The current-day creek has numerous potholes, flows between large tabular limestone outcrops, and varies from constrained to floodplain-type morphology. Potholes (karst) in the current-day creek are sandy and the deposits do not exhibit sorting. This morphology is similar to the poorly sorted matrix-supported gravels recognized in the paleochannels.

Exploration trenching and bulk sampling

Detailed exploration on the E4 A-channel project occurred during 2007 (Rockett, 2008). A pitting and trenching program identified two possible paleochannels (western and eastern) with gravel thicknesses of up to 4 m. Small bulk samples were collected at several localities along the channels and encouraging grades of up to 21.5 cpht were recorded from this initial program. Figure 36 and Table 7 summarize this work and the results.

Indicator mineral sampling

Indicator mineral sampling is a useful technique for determining whether an alluvial system may carry commercial quantities of diamonds. The indicator mineral population in current-day stream-sediment samples indicates the proximity to a lamproite body and the drainage direction. The abundance and size of minerals such as chromite (chrome spinel) and pyrope (garnet), as well as micro and macro (>0.4 mm) diamonds, are commonly proportionate to the grade of a bulk sample. Indicator mineral samples were taken from each of the bulk samples. The results and their comparison to diamond grades is summarized in Rockett (2009).

Test-pit indicator mineral sampling

Indicator mineral samples were taken from two test pits during the exploration program — one 110 m upstream (BDTP0452) and one 65 m downstream from the site of BLBS206 (BDTP0470). Table 8 summarizes these results.

Stream-sediment samples

Stream-sediment sample E4 A-Ch001 was collected from a site in the current-day drainage in 2006, and returned seven macrodiamonds greater than 0.4 mm. A further five stream-sediment samples were collected in 2007. All samples returned lamproitic chromites, three returned lamproitic pyrope, and two returned diamond. Table 9 presents a summary of these results (Rockett, 2008).

Surface geochemical sampling

In February 2007, additional geochemical sampling was undertaken targeting termite mounds in the area immediately to the north of the known niobium anomaly. The aim was to track the northern extension of the E4 A-channel project area. A total of 512 samples were taken and analysed for a suite of lamproitic elements consisting of Ba, Ce, Cr, La Nb, Nd, Ni, and Y. Figure 40 shows the extent of the surface geochemical sampling survey, and plots the niobium values. This shows an area of high response in the southwestern portion of the survey area and also in the northeastern portion to the south of Mount Percy.

Test-pit geochemical samples

Geochemical samples were taken from selected horizons in a range of test pits in the northern portion of the project area. These samples comprised a grab sample of material excavated from the test pit. Commonly the samples were taken in pairs, with one near the top of the alluvial sequence and the second from the base. Figure 40 presents the niobium values from these test-pit samples.

Geophysical technique trials

Use of ground-based electromagnetic conductivity (EM) as an exploration tool on the E4 A-channel project has a number of benefits. The technique is quicker and much cheaper than test pitting and trenching using an excavator. Two line-kilometres of close-spaced measurements can be achieved in a day compared to less than a 500 m of trenching with an excavator. It is also less damaging to the environment and equipment as trenching in limestone country is challenging. Test pitting and trenching will be required as follow-up, but this work would target specific areas of interest defined by the ground EM surveys.

The Geonics EM34-3 is able to measure changes in apparent conductivity both vertically and, to a limited extent, laterally. These changes in conductivity can be caused by several variables including watertable depth and salinity, porosity, and mineralogy. Of these variables, the major influence in the E4 A-channel area is the effect of clays in the gravels and the depth to the underlying Nullara Formation bedrock. As the alluvial system in this area is dominantly sandy clay with variable percentages of gravel, the high proportion of clays provides a response measurable by the EM34-3 unit. The orientation surveys undertaken over the E4 A-channel area correlated very well with the known extent of the paleochannel system. Ground-penetrating radar has not been trialled in the area and may also be an effective direct-imaging tool.

Channel interpretation

The western channel is interpreted to be older due to its deeper erosion of the surrounding limestone, with blocks of this bedrock falling into the paleocreek and trapping pockets of gravel underneath and in crevices. A strong calcretized layer overlies this initial sediment deposition, perhaps forming along a contact with later alluvial deposition. Minor transported laterite is found throughout the calcretized sandy-clay unit.

The eastern lateritic gravels are interpreted to be younger than the western gravels and do not display the same strong calcretized horizons typical of the western channel. The presence of large clasts of calcretized sandy clay and gravel in the base of the eastern channel suggests that erosion of the older western channel or headwaters may have taken place and eroded these into the eastern channel. The eastern channel is potholed and erratic. Further deposition, by either alluvial or colluvial means, has buried the channel headwaters in the south and perhaps eroded some of the channel further to the north.

Mining

There has been no large-scale bulk sampling or trial mining undertaken within the E4 A-channel project area.

Table 7. E4 A-channel alluvial project exploration bulk-sample results

Sample number	*Tonnes processed*	*Diamond size distribution (mm)*[(a)]		*Number of diamonds*	*Total carats*	*Average size (ct)*	*Grade (cpht)*	*Largest diamond*[(b)] *(ct)*
		+3.35	*–3.35*					
BLBS201A	88.00	0	42	42	2.30	0.05	2.61	–
BLBS201B	176.15	1	23	24	2.45	0.10	1.39	0.40
BLBS201C	116.20	5	114	119	11.71	0.10	10.08	0.72
BLBS201D	86.75	1	72	73	6.94	0.10	8.00	0.36
BLBS203A	49.20	1	12	13	1.28	0.10	2.60	0.60
BLBS203B	32.65	0	17	17	1.02	0.06	3.12	–
BLBS204	131.55	1	16	17	1.13	0.07	0.86	0.48
BLBS205A	124.65	0	6	6	0.84	0.14	0.67	–
BLBS205C	90.50	0	4	4	0.19	0.05	0.21	–
BLBS206	68.55	7	95	102	14.71	0.14	21.46	1.14
BLBS207	119.55	4	61	65	8.24	0.13	6.89	1.02
BLBS208	57.95	3	9	12	3.13	0.26	5.40	1.48
Total	**1 141.70**	**23**	**471**	**494**	**53.94**	**0.11**	**4.72**	**1.48**

NOTES: (a) Diamonds recovered from the –14 + 1.0 mm size fraction
(b) +3.35 mm
SOURCE: Rockett (2008)

Table 8. Indicator mineral results from the E4 A-channel exploration test pits

Sample number	*Head weight (kg)*	*Diamond (mm)*	*Chromite*[(a)] *(per 100 kg)*	*Pyrope*[(a)] *(per 100 kg)*
BDTP0452 (A075)	61.3	1 x +1.0 1 x +0.4 1 x +0.3 (total = 3)	20 732	15
BDTP0470 (A103)	52.3	0	6342	21

NOTE: (a) >0.5 mm
SOURCE: Rockett (2008)

Table 9. Indicator mineral results from the E4 A-channel stream-sediment samples

Sample number	*Year*	*Head weight (kg)*	*Diamond (mm)*	*Chromite*[(a)] *(per 100 kg)*	*Pyrope*[(a)] *(per 100 kg)*
E4 A-Ch001	2006	37.6	2 x +1.0 1 x +0.8 3 x +0.5 1 x +0.4 3 x +0.3 5 x –0.3 (total = 15)	n/a (chromite grains too numerous)	66
E4 A-Ch002	2007	46.20	3 x +1.0 2 x +0.8 4 x +0.5 1 x +0.4 1 x +0.3 (total = 11)	46 762	188
E4 A-Ch003	2007	43.20	0	10 810	2
E4 A-Ch004	2007	50.70	0	85	0
E4 A-Ch005	2007	44.10	0	2977	0
E4 A-Ch006	2007	37.80	2 x +1.0 5 x +0.5 2 x +0.4 2 x +0.3 (total = 11)	57 492	167

NOTE: (a) >0.5 mm
SOURCE: Rockett (2008)

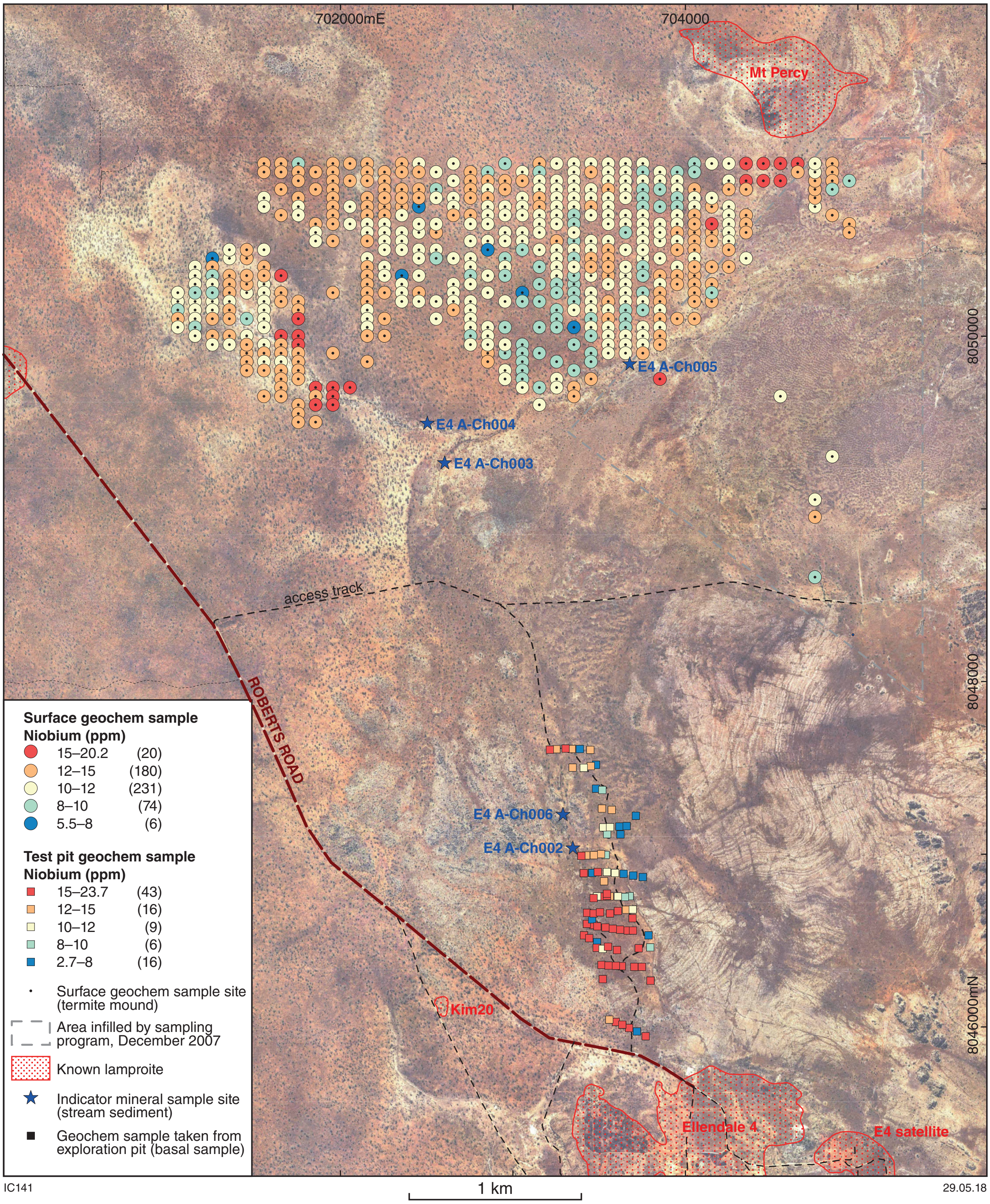

Figure 40. Surface and test-pit geochemical sampling on the E4 A-channel by Blina Diamonds NL (after Rockett, 2008)

Exploration potential

Although the initial exploration program was successful, significant deficiencies were recognized in the exploration procedure as working in a limestone environment presents significant operational challenges. In most test pits, carbonate cementing of the alluvial clasts made excavation extremely difficult and bedrock may not have been reached in many of the bulk-sample pits. The carbonate cement that is pervasive throughout the area causes logistical problems for processing alluvial gravels, with effective liberation of the diamonds problematic.

Further work is required to determine the volume of potentially diamondiferous gravels within the project area. Exploration work to date has defined relatively small concentrations of gravels in low areas within the limestone karst topography. It is questionable whether this represents a large-scale alluvial system with the potential for high-volume gravels.

E4 J-channel

The E4 J-channel project is located to the southwest of the E4 mining operations. The E4 lamproite sits close to a major drainage divide and areas to the north and south of the pipe have been explored for diamondiferous alluvial gravels.

The E4 J-channel project comprises gravels deposited in a broad valley. The gravels are known to extend over a length of 6 km, with channel widths ranging from 1 to 2 km. Gravel sequences up to 4 m thick have been identified and are covered by a variable thickness of eolian sand. The gravels are considerably older than those in the E4 A-channel project area, and pre-date the modern drainage divide (Jones, 2004). The E4 J-channel may be similar in age to the Terrace 5 gravels. Only the northern portion of the E4 J-channel lies on the Ellendale mining lease, with most exploration activity and sampling undertaken in areas off the former mining lease area. Figure 36 shows the location of the E4 J-channel relative to E4 and summarizes the more recent exploration results.

Geology

This summary of the E4 J-channel geology has been adapted from Jones (2004). The total preserved length of the E4 J-channel is approximately 6 km. The northern limit of this channel is erosional and lies in the headwaters of a modern northward-draining stream that is part of the Lennard River catchment. To the south, near Dome Hill (MGA 700000E 8040200N), outcropping basal gravels have been identified along a weak erosional escarpment that marks the southern edge of an ancient desert terrain. To the south, tributaries of Mount Wynne Creek have completely removed the E4 J-channel deposits. Gravels identified to the south of Dome Hill are probably recent outwash fans derived from the ancient E4 J-channel.

The valley hosting the E4 J-channel is up to 2 km wide and forms a broad basement low that is partially filled with red eolian sand. This sand drapes over the pre-existing landscape and the valley remains as a weak topographic low. Sand cover varies between 2 and 25 m in thickness and is thickest in the north. Drilling and pitting suggest that gravels are typically present in a zone about 500 m wide. Gravel is not continuous over this width and is invariably present as lenses. Drillholes and excavations often show several gravel horizons. Gravel lenses vary between 0.1 and 4.0 m in thickness with most averaging about 1 m thick. Diamonds tend to be concentrated in basal cobble to boulder conglomerates that directly overlie the sandstone basement comprising fluvioglacial sandstones and conglomerates of the Grant Group.

Basal conglomerate

The basal conglomerate is widespread and is present in both the deeper parts of the valley and also on the valley edges. Some of the better diamond grades have been derived from conglomerates along the edge of the paleovalley. This suggests that these gravels may mark a former channel base that has been preserved as the old river eroded deeper into basement rocks. The basal conglomerates are mostly clast-supported cobble and boulder conglomerates. The dominant clast lithology is a subangular to rounded siliceous sandstone. These relatively unusual clasts may have been derived from the rim rocks around the E4 lamproite. Mixed with the siliceous sandstone are well-rounded quartzite cobbles that are probably derived from conglomerate units within the Grant Group sandstone basement, and locally derived clasts of ferruginous sandstone. The matrix of the basal conglomerate is clay-rich pebbly sand.

Heavy mineral concentrates collected from the basal conglomerates are dominated by ironstone (>99%). Tourmaline and staurolite comprise most of the non-ironstone component of the heavy mineral fraction. In addition to diamond, lamproitic indicator minerals identified in heavy mineral concentrates include chromite, pyrope garnet and corundum. Overlying the basal gravels is a sequence of grey, pebbly sands with subordinate gravels and mudstones. These are relatively low-energy fluvial sediments that partially filled the E4 J-channel valley.

Diamonds

The majority of the diamonds recovered from E4 J-channel samples have almost certainly been derived from the E4 lamproite pipe and are very similar in colour and morphology. Small, white and off-white, strongly resorbed diamonds dominate the population (Fig. 41). The average size tends to be slightly larger than for E4, and there are also fewer fractured and irregular diamonds. This slight change in size and quality is typical of alluvial diamonds compared to their primary rock equivalents.

Diamond grades in the E4 J-channel samples are highly variable. Clast-supported basal conglomerates over 0.5 m thick that have been sampled returned grades commonly between 3 and 5 cpht. Other gravels within the sequence returned significantly lower grades. Insufficient diamonds have been recovered from the alluvial system to determine their potential value. Diamonds recovered by KDC from mining the E4 pipe sold for about US$156/ct. It is anticipated that diamonds from the E4 J-channel would achieve a similar or higher value.

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Figure 41. Diamonds recovered from sample MWBS1 at Dome Hill, southern end of the E4 J-channel (photo by D Jones)

Aircore drilling program

Prior to 2005, three lines of aircore drillholes were completed on the E4 J-channel project. The lines, 1 km apart, were orientated northwest to southeast, with drill-collar spacing mostly at 100 m.

Exploration pitting and bulk sampling

Follow-up to the aircore drill program comprised test pitting and bulk samples. Table 10 summarizes these early results and the pit locations are shown on Figure 36.

Bauer drilling program

In October 2006, Blina commenced a drill program in the E4 J-channel area using a BG20 drillrig. One hundred 1 m-diameter holes were drilled for 1186 m, along four lines across the alluvial system (BDLD2260–BDLD2359). The holes were mostly 50 m apart, with infill at 25 m where a significant change to bedrock was encountered. All four drill lines lie to the south of the original M04/372 boundary and supplemented earlier exploration work such as excavator test pitting and aircore drilling. The program provided a more accurate definition of the gravels and variations in the base-of-channel topography. As with the Terrace 5 Bauer program, each drillsite was located using a differential GPS, thus providing highly accurate position coordinates and vertical height. Although the density of data is not as detailed as the grid for the Terrace 5 program, the information relating to relative bedrock depths provides a better understanding of the E4 J-channel morphology than previously known.

Cross-sections compiled for each drill line show variation in the thickness of the overlying pindan sand and channel-sediment infill thickness, with the basal gravels being as deep as 18 m in places (Rockett, 2007). On the northernmost drill line (Line 1), E4 J-channel comprises a wide, deep channel with multiple horizons of both clast- and matrix-supported gravels. In most places, there is a lag gravel between the base of the pindan sand and the top of the alluvial sandy-clay sequence. Towards the south, the channel narrows and becomes more deeply incised; however, the depth of superficial cover such as pindan sand decreases. The gravels from two small tributaries or upper terraces intersected on the eastern end of Line 4 comprise highly lateritized clast-supported gravels. Figure 42 shows the cross-section for Line 3. Each Bauer drillhole was backfilled on completion of logging, and only the gravel portion of the stratigraphy was left on the surface for sampling.

Indicator mineral samples

Indicator mineral samples were taken from representative gravel horizons from each of the four Bauer 1-m drill lines. Thirty-two gravel intersections were sampled, and an additional subsample was taken from each bulk sample to enable grade and indicator mineral populations to be compared.

Geochemical sampling

Grab samples of drill spoil were taken from the base of the overburden and bedrock at the end of hole. A total of 136 overburden samples and 100 end-of-hole samples were analysed for a group of eight lamproitic elements comprising Ba, Ce, Cr, La Nb, Nd, Ni, and Y.

Bulk sampling

During 2006, KDC utilized a BG36 Bauer drillrig to bulk sample lamproites within the mining lease. Blina commissioned the use of this rig for a short program to sample the deeply buried gravels on the E4 J-channel identified from the 1-m Bauer drill program. The BG36 rig drilled a 2.5 m-diameter drillhole and was track mounted in a similar fashion to the BG20 (Fig. 43).

A cluster of 2.5 m-diameter holes were drilled at four selected bulk-sample sites. The gravel intersection from each hole was retained and stored as sample, and the drillhole backfilled with the remaining material. When more than one gravel horizon was intersected, the upper horizon was sampled separately as an A-sample, with the B-sample being the basal gravel.

Results

Although the gravels sampled looked impressive, with large quartzite cobbles, the grades returned were disappointing. Table 11 summarizes the 2006 results.

Exploration potential

The Bauer drill program during 2006 identified shallower gravel terraces along the flanks of the E4 J-channel valley. In late 2008, a bulk sample was excavated adjacent to BDLD2289 on the southern drill line. This sample targeted gravels from a shallower alluvial terrace, but it was not processed. Similar 'upper terrace' gravels are located close to BDLD2356, BDLD2357 and BDLD2338 on Line 1, the most northern Bauer drill line. These gravels may correlate with the northern bulk samples MWBS11, 12, 13 and 14.

The highest Nb values from the downhole geochemical samples also lie at the edges of the channel, which may add support to the diamond potential of the gravels in

Table 10. Summary of the E4 J-channel pre-2005 bulk-sample results

Sample ID	*Sample type*	*Tonnes*	*Carats*	*Number of stones*	*Average stone size (ct)*	*Grade (cpht)*
MWBS1	pit	192.1	10.03	40	0.25	5.22
MWBS2	pit	42.1	0	0	-	-
MWBS3	pit	122.2	0.11	1	0.11	0.09
MWBS4	pit	150.9	1.66	2	0.83	1.10
MWBS5	pit	164.8	5.72	25	0.23	3.47
MWBS7	trench	268.2	0.885	5	0.18	0.33
MWBS8	trench	534.6	0.695	6	0.12	0.13
MWBS9	trench	41.9	0.155	3	0.05	0.37
MWBS10	trench	61.4	0.70	6	0.12	1.14
MWBS11	trench	219.5	4.61	59	0.08	2.10
MWBS12	trench	81.4	0.48	3	0.16	0.59
MWBS13	trench	154.3	6.745	39	0.17	4.37
MWBS14	pit	360.8	12.485	79	0.16	3.46

SOURCE: Kimberley Diamond Company exploration data

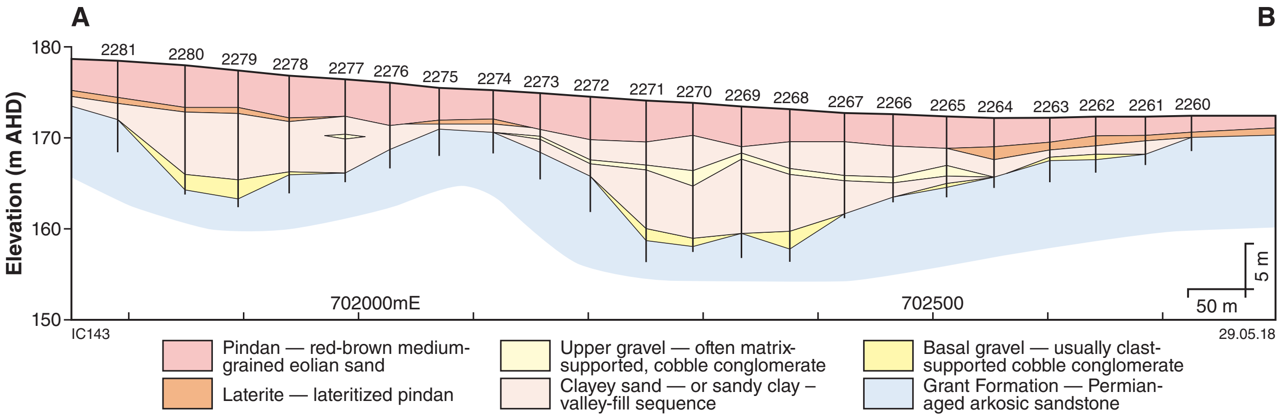

Figure 42. Geological cross-section through the E4 J-channel (after Rockett, 2007)

this portion of the channel. The shallow terrace gravels identified from the 2006 Bauer drill program remain untested for diamond content.

Further exploration potential also lies to the west of E4. This area has had limited work and may host an undetected alluvial channel.

E9 North western channel

The E9 North project developed from sterilization work in 2005 within the footprint of KDC's proposed northern waste dump (Williams, 2007). The work comprised test pits on a 50 x 200-m grid pattern over an area that covered two niobium geochemical anomalies defined from regional geochemical termite-mound sampling. The outcome of this exploration work was the discovery of two diamondiferous alluvial channels — the E9 North western channel and the E9 North eastern channel.

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Figure 43. Bauer BG36 rig in action on the E4 J-channel (photo by GMI Rockett)

The E9 North western channel has been mined over a distance of 800 m downstream from the northern edge of the E9 pipe, and has been delineated by exploration trenching and sampling for a further 300 m. Figure 44 shows the location of the E9 North western channel relative to the E9 lamproite pipe.

Geology

Extensive mapping has shown that the E9 North western channel is complex, with three subchannels identified (Fig. 45; Williams, 2007). The diamond grades and average stone sizes vary greatly between the subchannels.

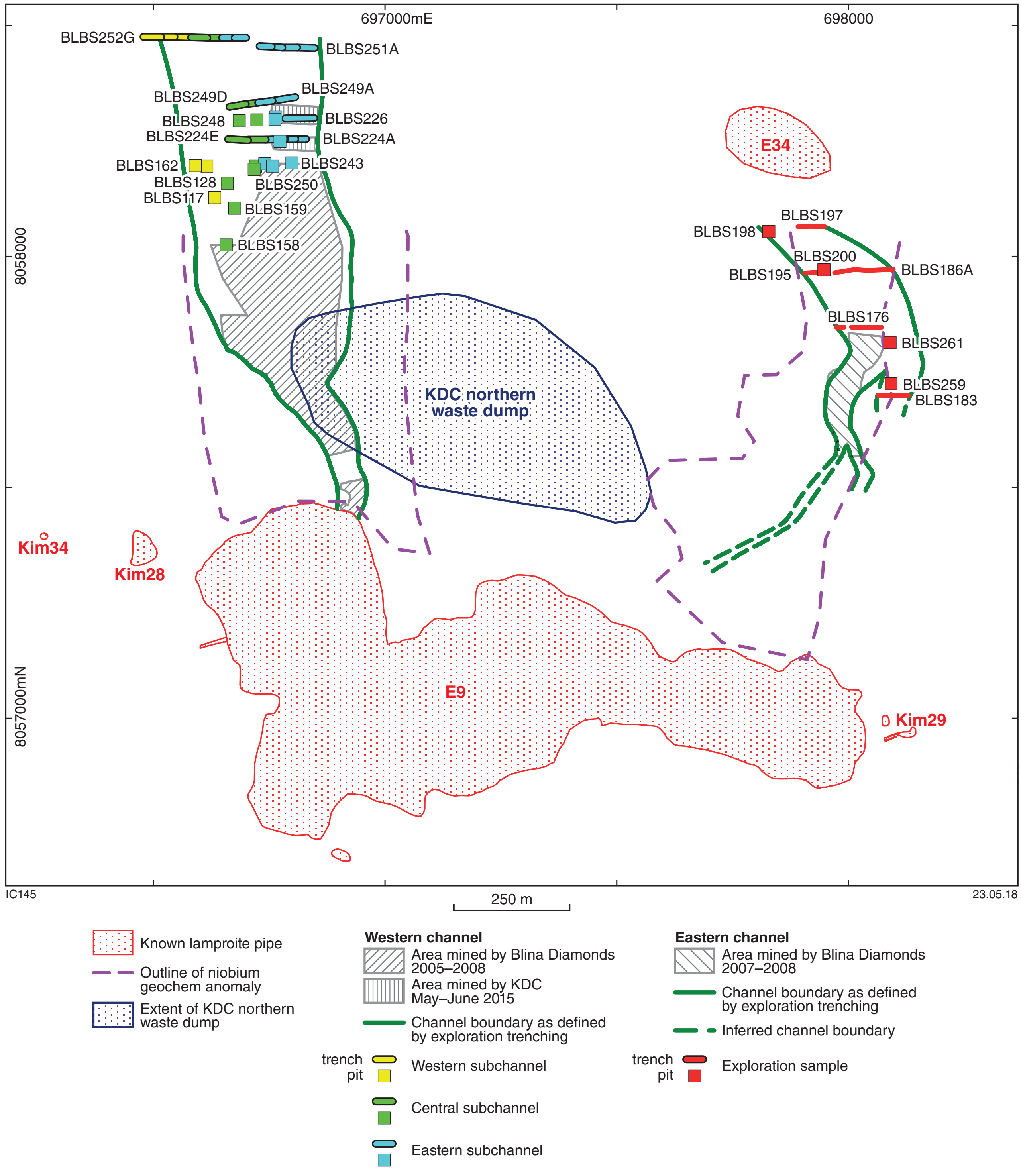

Figure 44. E9 North alluvial mining area

Table 11. Summary of the E4 J-channel 2006 bulk-sample results

Sample number	Tonnes processed	Total carats[(a)]	Number of diamonds	Average size (ct)	Grade (cpht)	Largest diamond[(b)] (ct)
Line 3						
BLBS187A	38.80	0	0	–	barren	–
BLBS187B	80.44	0.135	3	0.05	0.17	–
Line 2						
BLBS188A	19.40	0	0	–	barren	–
BLBS188B	74.95	1.250	6	0.21	1.67	0.55
Line 1						
BLBS189A	44.95	0.080	1	0.08	0.18	–
BLBS189B	indicator mineral sample only	n/a	n/a	n/a	n/a	n/a
BLBS189C	94.85	2.340	15	0.16	2.47	0.77
BLBS190	56.25	0.560	6	0.09	1.00	–

NOTES: (a) Diamonds recovered from the –14 + 1.0 mm size fraction
(b) +3.35 mm
SOURCE: Rockett (2008)

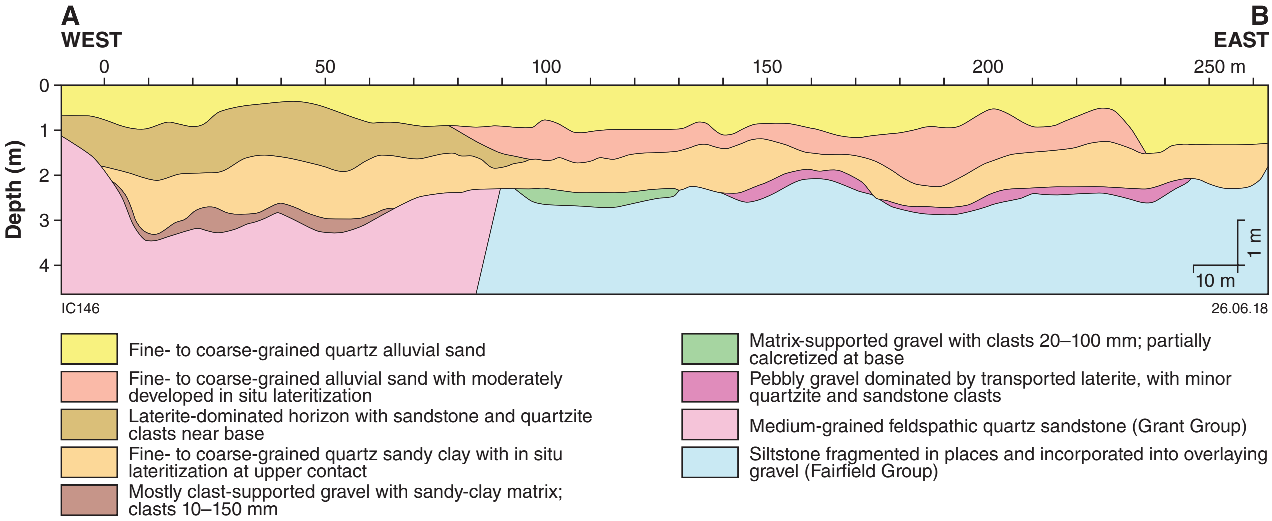

Figure 45. Geological cross-section through the E9 North western channel, showing the relationship between the three subchannels (after Williams, 2007)

Western subchannel

This subchannel comprises mostly clast-supported gravels with a variety of clast rock types; however, clast size declines and the gravel becomes more matrix-rich downstream, reflecting a drop in the gradient of the channel base and a subsequent fall in the channel velocity. As a result, diamond grades decrease, as does the average stone size. This gravel type carried the very high grades, such as 38.3 cpht, that were recovered in the 2005 mining operation. The gravel horizon is mostly about 0.4 – 0.6 m in thickness, although it reached nearly 1 m in places, and gravel thickness decreased downstream.

This subchannel is probably the oldest part of the system as it is overlain by a distinctive laterite grit horizon that has not developed over the other two subchannels (Fig. 46).

Figure 46. Clast-supported gravels with overlying lateritic grit from the western subchannel (photo by GMI Rockett)

The grit horizon comprises mostly in situ laterite with a low proportion of transported clasts concentrated near the base. It contains diamonds but low grade, less than 2 cpht, and has a small average stone size of less than 0.15 ct.

Central subchannel

This channel comprises matrix-supported pebbly, clay-rich gravels and is interpreted to be the youngest of the three subchannels. It contains more transported laterite and ferruginized sandstone than the western subchannel, but more sandstone, quartz and quartzite clasts than the eastern subchannel gravels (Fig. 47). Commonly, a bedrock high separates it from the western subchannel, but the boundary with the eastern subchannel is less clear. This gravel shows characteristics that suggest it has been reworked, possibly by the modern creek system. This is especially apparent in the upstream portion. The gravel varies in thickness, but mostly comprises a 0.3 – 0.4 m horizon. Exploration samples from this gravel returned grades from 8 to 23 cpht, and mining grades of 10–18 cpht.

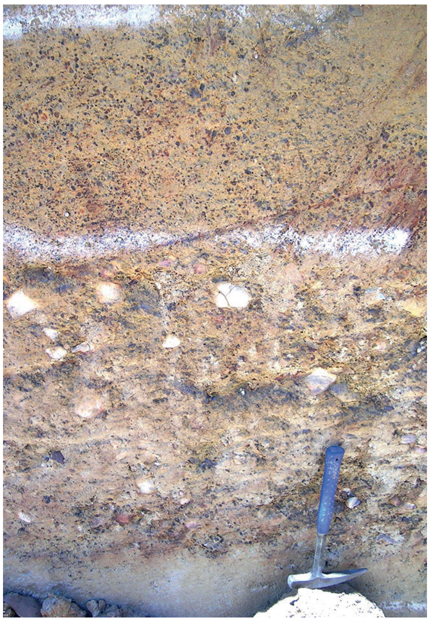

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Figure 47. Pebbly clay-rich matrix-supported gravel from the central subchannel (photo by GMI Rockett)

Eastern subchannel

This is the widest of the three subchannels and comprises clast-supported pebbly gravel that carried substantial grades of up to 52 cpht. The gravel is mostly transported laterite, but also contains some sandstone and quartz–quartzite pebbles and cobbles up to 100 mm in size, mostly concentrated near the base of the unit (Fig. 48). The gravel horizon is partially calcretized, especially at the basal contact with the underlying calcareous siltstone. Grades and average stone size remain encouraging over the entire channel as defined so far. The horizon rarely exceeds 0.3 m in thickness, hence to mine profitably the challenge is to extract the gravel without incorporating too much overburden or bedrock. Exploration samples from this gravel returned grades from 9 to 52 cpht, and mining grades of 10–22 cpht.

Exploration pitting and bulk sampling

Since discovery in 2005, the E9 North western channel has been extensively trenched, allowing detailed mapping of changes in the gravel types across the system and downstream (Fig. 49). Sampling of gravels excavated from the trenches, plus discrete bulk-sample pits, have provided good control on the grades and average stone sizes expected from the mining blocks. The channel system has been defined over a distance of 1.1 km from the northern edge of E9. This work has shown that grades and average stone sizes drop with distance from E9. Tables 12–14 summarize the bulk-sample results from the area downstream from the most northern 2008 mining blocks for each of the subchannels.

Indicator mineral sampling

Indicator mineral samples were taken from a selection of the mining block gravels excavated during the 2006, 2007 and 2008 mining campaigns. The purpose was to track downstream changes in the abundance and mineralogy of lamproitic indicators distributed in the alluvial system. Indicator mineral trends are a useful tool for determining the diamond potential of untested alluvial systems. Table 15 summarizes these results.

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Figure 48. Laterite-rich, clast-supported pebbly gravel from the eastern subchannel (photo by GMI Rockett)

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Figure 49. Trench sampling downstream on the E9 North western channel (photo by GMI Rockett)

Table 12. Summary of bulk-sample results from the western subchannel

Sample number	*Tonnes processed*	*Diamond size distribution (mm)*[(a)]		*Number of diamonds*	*Total carats*	*Average size (ct)*	*Grade (cpht)*	*Largest diamond (ct)*
		+3.35	*–3.35*					
BLBS117	58.7	3	21	24	4.02	0.17	6.85	0.66
BLBS252E	75.8	0	5	5	0.56	0.11	0.74	–
BLBS252F	40.7	0	3	3	0.50	0.17	1.23	–
BLBS252G	50.0	2	8	10	1.74	0.17	3.48	0.58
BLBS161	68.0	2	13	15	2.88	0.19	4.24	0.61
BLBS162	64.0	1	7	8	1.59	0.20	2.48	0.64
Total	**357.2**	**8**	**57**	**65**	**11.29**	**0.17**	**3.16**	**0.66**

NOTE: (a) Diamonds recovered from the –14 + 1.2 mm size fraction

SOURCES: Williams (2007); Williams and Rockett (2008)

Table 13. Summary of bulk-sample results from the central subchannel

Sample number	*Tonnes processed*	*Diamond size distribution (mm)*[(a)]		*Number of diamonds*	*Total carats*	*Average size (ct)*	*Grade (cpht)*	*Largest diamond (ct)*
		+3.35	*–3.35*					
BLBS128	263.55	11	48	59	12.24	0.21	4.64	0.88
BLBS158	46.5	6	19	25	6.95	0.28	14.95	1.3
BLBS159	102.8	8	32	40	8.67	0.22	8.43	1.19
BLBS175A	44.7	1	15	16	2.09	0.13	4.68	0.49
BLBS175B	87.4	2	44	46	7.19	0.16	8.23	–
BLBS224D	116.5	8	41	49	12.90	0.26	11.08	1.42
BLBS224E	71.5	2	24	26	4.70	0.18	6.57	0.84
BLBS245	70.5	13	58	71	17.04	0.24	24.19	3.7
BLBS247	58.0	2	17	19	4.37	0.23	7.53	0.72
BLBS248	46.8	3	11	14	3.95	0.28	8.45	1.32
BLBS249C	49.0	1	4	5	1.69	0.34	3.45	1.32
BLBS249D	20.4	0	6	6	0.51	0.09	2.50	–
BLBS250	62.9	4	24	28	4.83	0.17	7.68	0.79
BLBS252C	54.0	3	15	18	3.43	0.19	6.35	0.87
BLBS252D	88.9	4	18	22	3.78	0.17	4.25	0.65
Total	**1 183.45**	**68**	**376**	**444**	**94.34**	**0.21**	**7.97**	**1.42**

NOTE: (a) Diamonds recovered from the –14 + 1.2 mm size fraction

SOURCES: Williams (2007); Williams and Rockett (2008)

Table 14. Summary of bulk-sample results from the eastern subchannel

Sample number	Tonnes processed	Diamond size distribution (mm)[a] +3.35	Diamond size distribution (mm)[a] –3.35	Number of diamonds	Total carats	Average size (ct)	Grade (cpht)	Largest diamond (ct)
BLBS166B Tr	204.1	15	78	93	18.46	0.20	9.04	1.17
BLBS174	147.5	16	68	84	20.47	0.24	13.88	1.31
BLBS224A	57.2	2	9	11	1.84	0.17	3.22	0.71
BLBS224B	54.8	5	21	26	6.78	0.26	12.37	2.05
BLBS224C	80.4	6	24	30	7.83	0.26	9.74	2.78
BLBS226	62.8	3	25	28	5.03	0.18	8.01	1.19
BLBS243	80.4	6	32	38	9.23	0.24	11.48	0.84
BLBS244	66.7	5	21	26	5.82	0.22	8.73	1.33
BLBS246A	39.6	4	20	24	6.63	0.28	16.74	1.84
BLBS246B	164.2	2	22	24	4.69	0.20	2.86	0.81
BLBS249A	22.6	2	8	10	1.97	0.20	8.72	0.72
BLBS249B	53.6	3	24	27	4.96	0.18	9.25	1.12
BLBS251A	25.9	2	12	14	2.24	0.16	8.65	0.72
BLBS251B	39.4	0	27	27	3.03	0.11	7.69	–
BLBS251C	42.6	2	16	18	2.98	0.17	7.00	0.6
BLBS251D	60.3	3	17	20	3.03	0.15	5.03	0.72
BLBS252A	39.7	1	8	9	0.71	0.08	1.79	0.46
BLBS252B	39.2	0	10	10	0.99	0.10	2.53	–
Total	**1 280.6**	**77**	**442**	**519**	**106.69**	**0.21**	**8.33**	**2.78**

NOTE: (a) Diamonds recovered from the –14 + 1.2 mm size fraction
SOURCES: Williams (2007); Williams and Rockett (2008)

Table 15. Indicator mineral results for the western channel, E9 North alluvial project

Report year	Sample number	Distance from E9 (m)	Head weight (kg)	Diamond (mm)	Chromite[a] (per 100 kg)	Pyrope[a] (per 100 kg)	Mining block grade (cpht)	Average diamond size (ct)
				Eastern subchannel				
2007	E9N-EB-002	450	35.80	0	190	0	22.11	0.44
2007	E9N-EB-006	550	39.80	0	176	0	19.00	0.37
2008	E9N-EB-012	790	48.90	1 x +0.3mm	192	0	14.71	0.30
2008	E9N-EB-013	850	39.30	0	392	3	10.37	0.28
				Central subchannel				
2007	E9N-CB-003	500	34.90	0	398	0	10.01	0.32
2008	E9N-CB-007	580	38.30	0	637	0	18.13	0.35
				Western subchannel				
2007	E9N-WB-005	500	41.13	0	739	0	17.86	0.39
2007	E9N-WB-004	550	31.13	0	495	3	10.52	0.40

NOTE: (a) >0.5 mm
SOURCE: Rockett and Chambers (2009)

Although far from exhaustive, the dataset demonstrates differences in chromite populations, strongly supporting the interpretation that the alluvial system comprises three different subchannels, and that the western subchannel eroded a different part of the E9 lamproite compared to the eastern subchannel. Equally, the intermediate chromite population represented by the central subchannel sample supports the conclusion that this channel represents reworking of gravels from the western and eastern subchannels. As the chromite population increases the diamond grade drops, which suggests possible winnowing out and redeposition of chromites from upstream. Only the western subchannel appears to defy this trend, with the grade and chromite populations decreasing proportionally in the two samples processed.

Channel interpretation

Exploration trenching has shown that the alluvial channel widens considerably, from 70 m to over 150 m wide, about 300 m from the edge of E9. It continues to widen to over 300 m about 500 m from the pipe. The gradient of the channel base also decreases as the channel widens, and the edges become more diffuse and difficult to define at a distance of greater than 800 m. The channel is interpreted to represent the deposition of sediments derived from the lamproite pipe to the south that, at the time of deposition, would have been a topographical high. The system shares similar features to a 'prograding alluvial fan', with a widening of the system as the channel-base gradient reduces, decreasing grain size of the sediments, and the diffuse nature of the channel boundaries. Reworking of sediments within the system, as represented by the sediments of the central subchannel, also supports this interpretation.

The overlying sandy clay across all the gravel subchannels is younger again and probably represents later, lower energy sheet-flooding events. Based on mapping undertaken in trenches over 1.1 km from the northern edge of the lamproite pipe, it is interpreted that the E9 North western channel system continues to widen and eventually dissipates.

Mining

Small-scale mining on the E9 North western channel was carried out during 2005, 2006, 2007 and 2008 (Figs 50, 51). Table 16 summarizes the results from these four campaigns. The 2008 mining campaign by Blina Diamonds took the area excavated to some 800 m downstream from the northern edge of E9 (MGA 696790E 8058200N). In May–June 2015, KDC undertook a small mining campaign covering two areas further north from the area mined by Blina. The southern pit is about 0.3 ha and overlies the area defined by BLBS224A, BLBS224B, BLBS224C and BLBS244 within the eastern subchannel. The second pit covers about 0.4 ha and straddles the area where BLBS226 and BLBS246A and B were taken. It is not known whether the material excavated from this second pit was hauled to the plant site.

Although this mining activity is clearly visible on the November 2015 Google Earth image, no tonnes processed nor diamond recovery results have been identified to date and this is probably due to the work being undertaken immediately prior to KDC going into administration.

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Figure 50. Mining on the E9 North western channel about 300 m downstream from the northern edge of E9 (photo by A Ahmat)

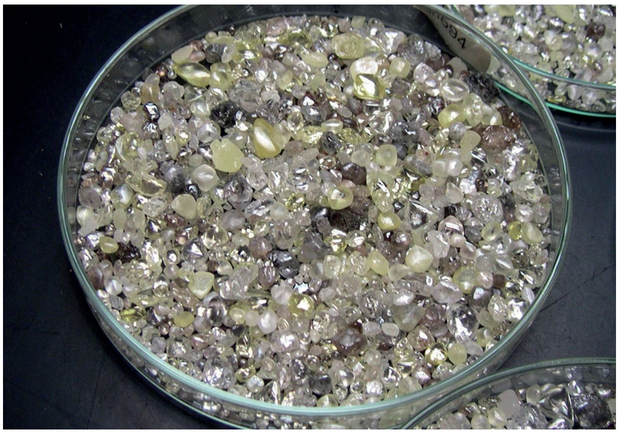

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Figure 51. Diamonds recovered from the 2005 mining campaign (photo by GMI Rockett)

Resource potential

The exploration bulk-sample results from 2007–08 indicate that the grade carried by the western subchannel has dropped to below 4 cpht, with an average stone size of 0.17 ct/stone. This low grade and small stone size is unlikely to be economic, especially as the strip ratio of overburden to gravel thickness is very high, with 2 m of overburden to 0.2 m of gravel thickness.

The central subchannel has a higher grade, with exploration samples averaging 7.97 cpht and an average stone size of 0.21 ct/stone. The largest diamond recovered from sampling was 1.42 ct. The strip ratio in this area is more encouraging with an average gravel thickness in the south of 0.4 m and an overburden thickness of 1.5 m. However, this deteriorates further downstream, with the most northern samples (BLBS252C and D) having a gravel thickness of 0.2 m under 1.7 – 2.0 m of overburden.

Table 16. Summary of mining results for the western channel, E9 North alluvial project

Sample number	*Tonnes processed*	*Diamond size distribution (mm)[(a)]*		*Number of diamonds*	*Total carats*	*Average size (ct)*	*Grade (cpht)*	*Largest diamond (cts)*
		+3.35	*–3.35*					
2005 Mining	49 603	6566	17 336	23 902	8994.86	0.38	18.13	9.92
2006 Mining	26 185	3579	6759	10 338	4091.03	0.40	15.62	11.4
2007 Mining	51 600	9863	15 902	25 765	8926.17	0.35	17.30	5.82
2008 Mining	31 568	4977	9946	14 923	4469.57	0.30	14.16	5.71
Total	**158 956**	**24 985**	**49 943**	**74 928**	**26 481.63**	**0.35**	**16.66**	**11.4**

NOTE: (a) Diamonds recovered from the –14 + 1.5 mm size fraction

SOURCE: Rockett and Chambers (2009)

Based on the 2007–08 exploration sampling, the eastern subchannel holds the best potential for an economic resource. The bulk sampling from this channel had an average grade of 8.33 cpht with an average stone size of 0.21 ct/stone. The largest diamond was a 2.78 ct stone recovered from a sample in the southern portion of the area. The gravel is 0.4 m thick with an overburden of 1.4 m for about 100 m, but the overburden thickness increases to nearly 2 m and the gravel thickness drops to 0.2 m further downstream. For this project to remain economically viable, the method of stripping overburden must be efficient yet sufficiently sensitive not to remove the target gravel horizon. The potential resource estimate for the E9 North western channel is presented in Table 17. The diamond value for western channel diamonds in 2008 was US$162/ct.

Additional exploration trenching at 50-m line spacing will establish whether the channel re-forms or continues to fan out and the gravels thin. Given the nature of the alluvial system, there is limited additional exploration potential.

E9 North eastern channel

The eastern channel of the E9 North project was initially identified in late 2005, with a single trench bulk sample. Exploration continued over three years, but the extent and continuity of the eastern channel proved difficult to establish. Exploration programs had some success with defining the channel structure, which has now been traced over a distance of about 700 m. Bulk-sample results show that significant diamonds are concentrated in most gravel horizons throughout the alluvial sequence. Exploration to date suggests that the channel flowed northwards and drained the eastern lobe of the E9 pipe where KDC recovered a significant proportion of their high-value ‘fancy yellow’ stones. Figure 44 shows the location of the E9 North eastern channel relative to the E9 lamproite pipe.

Geology

The alluvial channel contains diamondiferous gravels within a deeply incised, narrow paleochannel. The channel sequence comprises a series of gravel horizons separated by sandy-clay sequences. The total thickness of the alluvial package varies across the width of the system and is locally over 4 m thick. Exploration programs have shown it to be a complex system with secondary channels joining the main channel, and with reworking of gravel horizons at the confluence common.

The profile can be described as a curved ‘V’ shape. The shallow edges of the channel only contain the upper gravel horizon (horizon A). This horizon comprises mostly transported laterite and ferruginized fine-grained sandstone, with minor yellow-white sandstone and quartzite cobbles, overlain by sandy clay containing a combination of transported laterite nodules and in situ laterite. This alluvial package is usually about 0.5 m in thickness and overlain by up to 1 m of alluvial sand that is lateritized near the base. Horizon A sits onto bedrock in the shallow channel sections of the system, but also forms the upper gravel horizon in the deeper channel sections. The channel then slopes gently downwards towards the centre, and a second gravel horizon (horizon B) has developed as the basal gravel on these ‘shoulders’. Horizon B is mostly matrix-supported gravel with transported laterite, quartzite, and sandstone cobbles. Clast sizes are normally 20–50 mm.

The central portion of the channel is more deeply incised and comprises a narrow gully as much as 3 m deeper than the rest of the channel. In these sections, the alluvial sequence comprises the upper two horizons separated by sandy-clay units, and overlying a third basal gravel horizon. Horizon C is similar in clast-type to horizon B, but usually much coarser with average clast sizes being 50–150 mm. In places, this deeply incised section of the channel can be filled with a jumble of alluvial material, with no clearly defined separation between horizon B and horizon C, especially when the basal gravel thickens upwards at bends in the channel. Figure 52 shows the three gravel horizons in the deeply incised portion of the channel, and Figure 53 is a cross-section through the channel system showing the relationship between the three gravel horizons 570 m downstream from the northern edge of E9 (MGA 697980E 8057645N).

Exploration trenching and bulk sampling

The eastern channel was originally discovered in mid-2005, but only minimal exploration was undertaken as most focus was placed on the western channel. An extensive trenching program over 2006 to 2008 showed that the alluvial system consists of a thick channel sequence that has been traced over 700 m in length. The channel is open to both the north and south of the area explored to date.

Trench samples were split into sections according to what portion of the creek they intersected. For example, BLBS176A has sampled horizon A and B, whereas BLBS176B sampled horizon A, B and C. The sandy-clay layers were included with the gravel horizons, so the trench grades tend to be lower. More control was possible over the pit samples, where the sandy-clay horizon was removed and the layered samples represented the grades of the gravel horizons. Bulk-sample results showed that significant diamonds are concentrated in most gravel horizons throughout the alluvial sequence. However, as with the E9 North western channel, the alluvial system widens downstream, with the amount of overburden increasing to more than 2 m and grades and average diamond stone size decreasing.

Table 18 summarizes the bulk-sample results downstream from the 2008 mining blocks and the sections of the system that have not been mined. The deepest portion of the northern trench did not reach bedrock, so that sample (BLBS197C) was not hauled and processed.

Table 17. Resource estimate for the E9 North western channel

Subchannel	*Area (ha)*	*Estimated average thickness (m)*	*Estimated volume (m^3)*	*Estimated tonnes*	*Estimated grade (cpht)*	*Estimated carats*	*Estimated average diamond size (ct)*
Central	3.9	0.25	9750	17 000	7.97	1355	0.21
Eastern	4.0	0.30	12 000	21 000	8.33	1750	0.21

SOURCE: Blina Diamonds NL exploration data

Table 18. Bulk-sample results for the eastern channel, E9 North project

Sample number	*Sample type*	*Channel horizons*	*Tonnes processed*	*Diamond size distribution (mm)*[(a)]		*Number of diamonds*	*Total carats*	*Average size (cts)*	*Grade (cpht)*	*Largest diamond (cts)*
				+3.35	*–3.35*					
BLBS176A	trench	A, B	39.0	1	9	10	1.28	0.13	3.28	0.52
BLBS176B	trench	A, B, C	128.8	1	2	3	1.52	0.51	1.18	1.17
BLBS183C	trench	A, B	39.9	1	0	1	1.45	1.45	3.63	1.45
BLBS186A	trench	A	47.6	0	1	1	0.19	0.19	0.40	–
BLBS186B	trench	A, B, C	235.3	2	1	3	0.81	0.27	0.34	0.56
BLBS186C	trench	A, B, C	360.1	5	17	22	5.88	0.27	1.63	1.80
BLBS195	trench	A, B, C	96.3	0	3	3	0.43	0.14	0.45	–
BLBS197A	trench	A, B	50.1	1	3	4	1.22	0.31	2.44	0.47
BLBS197B	trench	A, B	72.1	2	3	5	1.37	0.27	1.90	0.47
BLBS198A	pit	A	119.0	0	0	0	0	n/a	barren	–
BLBS198B	pit	B	131.3	0	3	3	0.07	0.02	0.05	–
BLBS198C	pit	C	210.8	1	6	7	1.29	0.18	0.61	0.41
BLBS200A	pit	A	66.6	1	2	3	0.99	0.33	1.49	0.69
BLBS200B	pit	B	107.9	3	7	10	3.38	0.34	3.13	1.08
BLBS200C	pit	sandy clay	114.7	0	1	1	0.04	0.04	0.03	–
BLBS200C	pit	C	125.0	0	11	11	0.72	0.07	0.58	–
BLBS259A	pit	B	34.5	0	1	1	0.08	0.08	0.23	–
BLBS259B	pit	C	48.1	0	3	3	0.16	0.05	0.33	–
BLBS261A	pit	A	37.6	0	3	3	0.48	0.16	1.28	–
BLBS261B	pit	B	46.3	0	2	2	0.48	0.24	1.04	–
Total			**2110.6**	**18**	**78**	**96**	**21.83**	**0.23**	**1.03**	**1.80**

NOTE: (a) Diamonds recovered from the –14 + 1.2 mm size fraction

SOURCES: Williams (2007); Williams and Rockett (2008)

Figure 52. Northern wall of BLBS180, showing the three gravel horizons (photo by GMI Rockett)

Mining

Small-scale mining on the E9 North eastern channel occurred during 2007 and 2008. In 2007, in order to test the economic potential of the channel, 12 000 t of alluvial gravels were mined from the southern section of the alluvial system (Fig. 54):

- E9N-East-1A (Table 19) represents the A-horizon gravel, and its surface area was the largest of the three samples;
- E9N-East-1B represents the B-horizon gravel. The lower grade is interpreted to result from the higher proportion of sandy-clay channel-fill material that was incorporated in this sample; and
- E9N-East-1C represents the C-horizon gravel. The basal gravel was poorly developed in the southeastern 'arm' of the pit, and hence was combined with the B-sample in this section.

The average grade for the three gravel horizons was 5.44 cpht, with an average diamond size of 0.49 ct/stone. The largest stone, a 5.94 ct 'fancy yellow' gem, was recovered from ROM pad clean-up and hence it is not known from which horizon it was sourced. A number of yellow stones above 3 ct were also recovered. The high average stone size of the three mining samples is very encouraging. Diamonds from these samples and the exploration samples were combined into a parcel of 833.11 ct and submitted for valuation in early 2008. The value returned was US$471/ct. This parcel sold in early April 2008 for US$498/ct, adding further support to the economic potential of this system.

In view of the results from the 2007 trial mining campaign, and results from 2008 exploration sampling, Blina continued trial mining downstream on the alluvial system. During the year, an additional 25 000 t of alluvial ore was excavated and hauled for processing (Rockett and Chambers, 2009). In order to minimize internal waste and simplify mining, horizon A was taken as a discrete sample, but horizon B and C were combined. If the sandy-clay layer separating the lower two horizons was well developed, it was removed as waste. The channel was progressively backfilled as mining moved downstream.

Table 19 summarizes the results of all the mining blocks and shows that mining grades remained reasonable as the work progressed downstream. By the end of 2008, over 43 000 t of alluvial ore had been excavated and processed from the eastern channel, returning 2307.12 ct for 5363 stones, with an overall average stone size of 0.43 cts/stone.

The average stone size and quality of diamonds recovered has remained encouraging, with a 7.05 cpht grade returned by the basal gravel from the northernmost mining block (E9N-East-04B). This is one of the highest grades recovered from this system and indicates that the channel is maintaining energy downstream. The basal gravel exposed in the northern face of mining block 4 was nearly a metre thick. A highlight of the 2008 program was the recovery of a 9.06 ct yellow gem — the largest stone recovered from this system (Fig. 55).

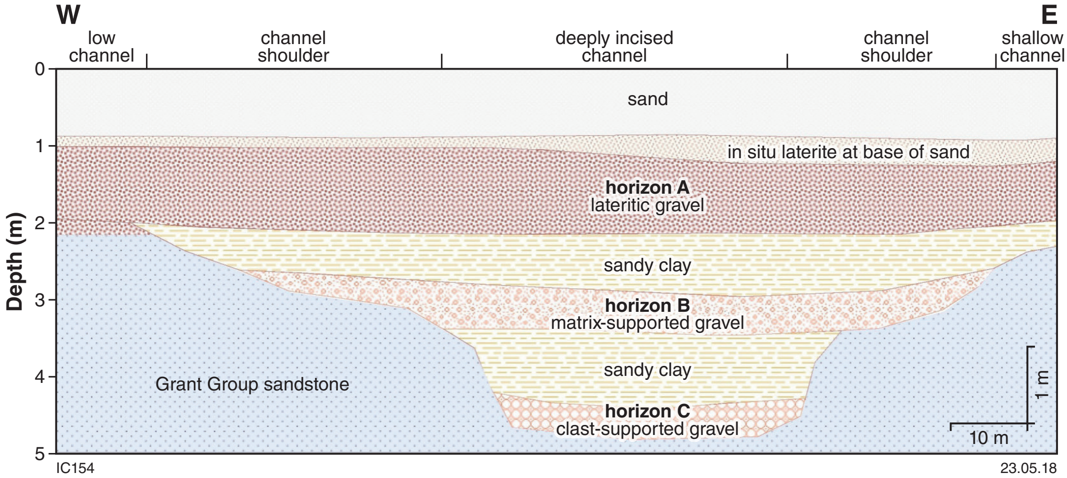

Figure 53. Cross-section through the channel system showing the relationship between the three gravel horizons

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Figure 54. **View from the northern edge of the E9 N-East 1 mining block, looking south along the channel bed (photo by GMI Rockett)**

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Figure 55. **Diamonds recovered from the E9 North eastern channel 2008 campaign. The largest stone recovered, a 9.06 carat yellow gem, at bottom LHS (photo by JD Ward)**

Table 19. E9 North eastern channel mining and exploration summary for 2007–08

Sample number	*Year*	*Tonnes processed*	*Diamond size distribution (mm)*[(a)]		*Number of diamonds*	*Total carats*	*Average size (ct)*	*Grade (cpht)*	*Largest diamond (ct)*
			+3.35	*–3.35*					
E9N-East-1A	2007	3723	292	346	638	286.44	0.45	7.69	3.97
E9N-East-1B	2007	6275	212	239	451	233.98	0.52	3.73	4.65
E9N-East-1C	2007	2207	136	140	276	143.84	0.52	6.52	3.48
E9N-East 01 overall grade	*2007*	*12 205*	*640*	*725*	*1365*	*664.26*	*0.49*	*5.44*	*4.65*
E9N-East exploration	2007	4813	163	339	502	168.86	0.34	3.51	5.94
Total for 2007		**17 018**	**803**	**1064**	**1867**	**833.12**	**0.45**	**4.90**	**5.94**
E9N-East-2A	2008	2460	226	237	463	215.51	0.47	8.76	9.06
E9N-East-2B	2008	9421	438	765	1203	461.41	0.38	4.90	5.99
E9N-East 02 overall grade	*2008*	*11 881*	*664*	*1002*	*1666*	*676.91*	*0.41*	*5.70*	*4.65*
E9N-East-3A	2008	2988	139	233	372	133.05	0.36	4.45	2.60
E9N-East-3B	2008	3654	204	301	505	218.57	0.43	5.98	4.65
E9N-East 03 overall grade	*2008*	*6642*	*343*	*534*	*877*	*351.61*	*0.40*	*5.29*	*4.65*
E9N-East-4A	2008	1664	31	93	124	51.53	0.42	3.10	3.43
E9N-East-4B	2008	4835	266	428	694	340.97	0.49	7.05	3.95
E9N-East 04 overall grade	*2008*	*6499*	*297*	*521*	*818*	*392.50*	*0.48*	*6.04*	*3.95*
E9N-East exploration	2008	1197	36	99	135	52.98	0.39	4.43	3.94
Total for 2008		**26 219**	**1340**	**2156**	**3496**	**1474.00**	**0.42**	**5.62**	**9.06**
Total for 2007–08		**43 237**	**2143**	**3220**	**5363**	**2307.12**	**0.43**	**5.34**	**9.06**

NOTE: (a) Diamonds recovered from the –14 + 1.5 mm size fraction for mining, and –14 + 1.0 mm size fraction for exploration
SOURCE: Rockett and Chambers (2009)

By the end of 2008, the paleochannel had been mined over a distance of 280 m and was open to the north, with potential for grades and high average stones sizes continuing downstream. The system is also open to the south (upstream), with the headwaters interpreted as coming from the eastern end of the Ellendale 9 lamproite, but as yet the channel has not been tracked to the edge of the pipe. No further exploration or mining has been carried out since the 2008 campaign.

Resource potential

Exploration trenching is sparse further downstream from the northern edge of the mined area. The exploration bulk-sample results from 2007–08 indicate that the grade drops off significantly to below 4 cpht, with the average stone size down to 0.23 ct/stone. However, sample density is sparse, with only three trenches over 100 m apart. Before committing to further mining downstream, the area needs additional trenching and mapping of the gravel sequence.

The high number of 'fancy yellow' stones greatly increases the value of this alluvial resource. The 2008 Venmyn technical statement for Blina Diamonds NL (Telfer, 2009) determined an in situ volume of 16 000 m^3 or 27 200 t, with a recovered grade of 9.11ct/100 m^3. This estimate is probably on the high end when compared to the exploration data available.

Exploration potential

Additional exploration trenching at 25-m line spacing will establish the edges of the channel and the position, plus the width of the deeper channel. The eastern channel arms (with a confluence at MGA 698000E 8057590N and 698080E 8057750N) warrant additional exploration as both may lead back to the eastern end of the E9 pipe that is interpreted to be the source of the high proportion of 'fancy yellows' in the alluvial diamond package.

Diamonds

Diamonds from the Ellendale project have been highly prized for their 'fancy yellow' colours and have commanded a high price during previous mining operations. Diamond size distribution greatly influences the diamond values and Figure 56 shows the differences between the size distribution of diamonds recovered from E4 and those from E9. The diamonds from Ellendale are lustrous and of high clarity and predominantly consist of yellow, shiny-surfaced, rounded dodecahedra (Hughes and Smith 1990; Fig. 57). In the coarser sizes, there is a trend towards remnant octahedral shapes and in the smaller sizes planar, unresorbed, pale-brown and white frosted octahedra are present (Fig. 58).

As the mining data was not available at the time of compiling this report, little information is available on the production size range utilized by the KDC processing plants. Hence, there is limited information available on the production size or value distributions.

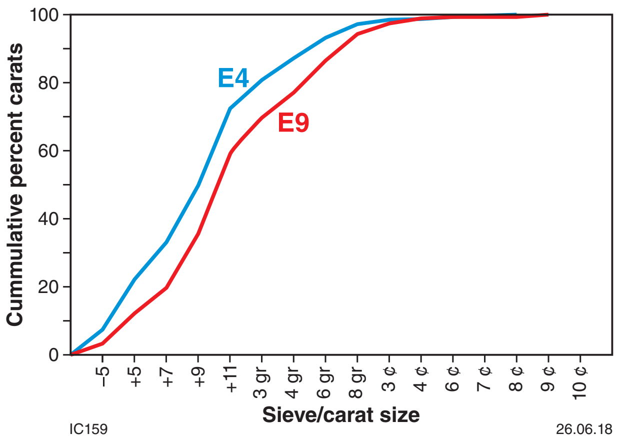

Figure 56. Diamond size distribution for E4 and E9 (modified from Telfer and McKenna, 2011)

Figure 57. Diamonds from E9 (photo by N Yiannopoulos)

Figure 58. Diamonds from E9 (photo by J Ward)

Processing method

In 2005, Blina established a processing site near Cut 1 where the company's exploration samples, large-scale bulk samples and trial-mining alluvial ore were processed. The void left by the excavation of Cut 1 across Terrace 5 was used as the tailing facility for the plant site. This processing site housed three separate processing plants — two 10-tph DMS processing plants and a larger 50-tph production DMS processing plant.

Processing of all Blina's exploration bulk samples and grade-control samples (mostly 200 t or less) was undertaken through the 10-tph exploration DMS plant (Fig. 59). The plant utilized a scrubber with a trommel that screened off oversize at 14 mm. The lower screen size was 1.2 mm with the finer fraction reporting to the tailings dam, and the –14 mm to +1.2 mm product introduced to the DMS circuit. In 2007, the lower screen size was changed to 1.0 mm. The concentrate derived from these samples was collected in bulkabags and transported to KDC's recovery section for processing through a twin-stage Flow Sort X-ray machine. Final recovery was carried out by hand-sorting, usually in the presence of a senior member of Blina's staff.

The second 10-tph DMS processing plant, known as the 'development plant', was utilized for processing lamproite-exploration and grade-control samples on behalf of KDC. The recovered size range for this plant was –14 mm to +1.2 mm. The concentrate from samples processed through this plant was also collected in bulkabags and final diamond recovery undertaken by KDC's recovery section.

All large bulk samples, such as those from Cut 1, Cut 2, E12 Alluvials, E9 North eastern channel and the 2006 onwards portion of ore mined from the E9 North western channel, were processed through Blina's 50-tph production DMS processing plant (Fig. 60). This plant had a 100-mm scalping screen and a 16-mm trommel to remove oversize prior to processing through the DMS plant, with a lower screen size of 1.5 mm. All –1.5 mm reported to the tailings dam. In 2007, the trommel screen size was reduced to 14 mm. From 2005 to 2006, the DMS concentrate was collected in bulkabags and sent to the KDC recovery section for diamond recovery.

In 2007, Blina Diamonds installed a modular final-recovery unit comprising two twin-stage Flow Sort X-ray machines. Concentrate from the production plant was then fed directly into the Flow Sort recovery unit. The system delivered dried X-ray product to a locked box. This product was then hand-sorted at the KDC recovery site to recover the diamonds.

In 2005, ore mined from the southern portion of the E9 North western channel was trucked to KDC's west plant for processing. Excavation of all diamondiferous gravels from this area was a priority due to KDC's expansion requirements that necessitated extension of the waste dump over the alluvial channel as soon as possible. To facilitate this requirement, Blina negotiated an arrangement with KDC whereby Blina would excavate and truck the gravels, and then pay KDC to process the material and recover the diamonds. In 2006, following modifications to Blina's production plant that increased the throughput to 75 tph, the company commenced hauling the E9 North alluvial ore to the Blina ROM using triple road trains.

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Figure 59. Blina Diamonds' 10-tph dense-media separation exploration plant (photo by D Jones)

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Figure 60. Blina Diamonds' 50-tph dense-media separation production plant (photo by D Jones)

Mineral resource and reserve estimates

Resources

The estimation of the mineral resources is fully described in the Venmyn report (Telfer and McKenna, 2011) and is summarized in Table 20. Modelling of the E4, E4S and E9 deposits has utilized drilling and mapping to determine geological boundaries for block modelling. A model block size of 25 × 25 m was chosen for all models. The grade estimation at E9 is based upon in-pit bulk-sampling data. The E4S pipe was geologically wireframed and kriged models created. The estimation of the floats stockpile was based on an average sample grade weighted by sample size for each of the separate dumps. The grade of the LG2 low-grade stockpile was derived from actual production results between September and October 2013. The grade of the LG1 low-grade stockpile was made by using 50% of the average mined grade prior to 2010 and was based on an assigned grade of 5 cpht. The grade estimation of the alluvial resources was calculated by averaging selected subsamples. Higher diamond grades are typically concentrated near the base of the alluvial gravels.

Table 20. Resource assessment for the Ellendale project

Resource	*Class*	*Tonnage (Mt)*	*Grade (cpht)*	*Carats (kct)*	*Value (US$/ct)*
E4	indicated	4.0	6.7	265	156
E9	indicated	5.1	3.7	186	706
ROM stockpiles	indicated	0.7	7.6	55	180
Total indicated		9.7	5.2	506	361
E4	inferred	10.3	6.1	632	156
E9	inferred	1.4	3.5	47	706
E4S	inferred	13.1	5.5	725	210
Low-grade stockpiles	inferred	1.8	2.5	44	210
Lights stockpile	inferred	12.4	0.8	103	682
Alluvials	inferred	0.4	4.29	18	643
Total inferred		39.3	4.0	1 569	239
Total Ellendale		**49.1**	**4.2**	**2 075**	**269**

SOURCE: Kimberley Diamonds Ltd (2015)

Reserves

The conversion of the mineral resource to reserve depends upon the value assigned to the diamond production and then to an estimation of an in situ value per tonne of the mineralized material. No reserves are stated at this time due to uncertainties of mining and processing costs and realised diamond value.

Market studies and contracts

No mining or processing is being undertaken at this time and no marketing contracts are current.

When in production, KDC and KDL sold the ‘Tiffany Quality’ (TQ) fancy yellow diamonds from E4 and E9 under a life-of-mine agreement with Laurelton Diamonds Inc., a subsidiary of Tiffany and Co. These diamonds attracted a high price premium above the average Ellendale diamonds market value. The TQ diamonds historically comprise approximately 9%, 16% and 1% of the total diamonds derived from the E9 west pit, E9 east pit and the E4 pipe respectively. The balance of production was sold by auction in Antwerp. The prices used in any economic assessment will require adjustment to reflect current market conditions.

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GEOLOGY, RESOURCES AND EXPLORATION POTENTIAL OF THE ELLENDALE DIAMOND PROJECT, WEST KIMBERLEY, WESTERN AUSTRALIA

Boxer and Rockett