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– ARTICLE –

The geological occurrence and visual attributes of sedimentary and 'volcanic' cherts in northern New Zealand

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Abstract

The northern part of the North Island of New Zealand includes numerous occurrences of chert, some of which are known to have been exploited by pre-European Māori. Most of the chert is of sedimentary origin, of Late Cretaceous-Eocene age, but Miocene 'volcanic' chert (i.e. jasper, sinter and silicified wood) is also common in places. To facilitate a better understanding of cherts in this region, and promote further research, the geological context and visual attributes of samples from 19 locations are described. Five different chert types are formally recognised. Visual examination of >160 samples show there is considerable overlap in the colour range of cherts from different localities, indicating that attribution of artefacts to specific sources based on colour alone is likely to be unreliable. However, a distinction between sedimentary and 'volcanic' cherts and sinters should be possible based upon the presence/absence of bioturbation, radiolaria and plant remains.

***Keywords*:** chert, sedimentary, volcanic, sinter, Northland, Coromandel Peninsula

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1. Introduction

Chert is relatively common in parts of New Zealand (Moore 1977, 1983, 2021), and was widely utilised by pre-European Māori for drill points and cutting and scraping tools, particularly during the early period of settlement (circa AD 1300–1500; Walter et al. 2010). However, archaeological research into sources of the chert has been very limited, and mainly confined to the description of specific occurrences (e.g. Frederickson 1990; Keyes 1970; Moore & Wilkes 2005). Additionally, very few analyses of chert artefact assemblages have been carried out, most of which were concerned with sedimentary cherts only, while those typically formed in terrestrial volcanic settings (including jasper, petrified wood and sinter) have been largely overlooked. Geological interest in New Zealand cherts has also been generally restricted to those within Mesozoic greywacke basement terranes (e.g. Sporli et al. 2007) and Late Cretaceous-Eocene limestone (Lawrence 1993).

This study provides new information on the geological context, distribution and visual attributes of both sedimentary and 'volcanic' cherts from 19 locations in the Northland, Auckland and Coromandel regions of the North Island (Figure 1). Five different chert types are formally recognised. Here, the importance of having some understanding of chert types and potential chert sources prior to undertaking any significant sourcing studies of artefact assemblages is emphasised. While there are many more known occurrences of chert, the present study is primarily concerned with those that would have been readily accessible and hence more likely to have been exploited by Māori communities in the past.

2. Terminology

Chert is generally defined as a siliceous sedimentary rock in which the silica (microcrystalline quartz or chalcedony) is primarily if not entirely biogenic in origin, but it can also form in terrestrial volcanic environments as a result of hydrothermal activity, where the silica is inorganic (Hesse 1989; Luedtke 1992; Mortimer et al. 2011). Petrified (silicified) wood, formed mainly through silica deposition from circulating ground water, is also common in some subaerial volcanic sequences (e.g. Moore & Wallace 2000). Although it is clearly helpful, from an archaeological viewpoint, to make a distinction between cherts of different origin, this may prove quite difficult when it comes to examining artefact assemblages where the geological context is unknown. Consequently, I have opted to make a simple, informal division into "sedimentary chert" and "volcanic chert", with the latter including both jasper and highly silicified wood, and other chert-like rock types such as silicified tuff, which typically occur in volcanic settings. This category also includes some older siliceous sinter deposits.

There is some debate over the definition and use of the term "jasper", but I have followed Luedtke (1992) in regarding it as a variety of chert, typically of red or brown colour but also yellow or green. I also consider the term should generally apply to chert formed through hydrothermal activity (Mortimer et al. 2011). Use of the term "flint" for black or grey chert associated with limestones is confusing and no longer widely used, and should be abandoned.

3. Geological context

The northern part of the North Island (Northland, Auckland and Coromandel Peninsula) is a region of complex geology containing a wide variety of rock types. In simple terms it consists of a "basement" of well-indurated Mesozoic greywacke, overlain by sequences of clastic to calcareous sedimentary strata and submarine to subaerial volcanics (Edbrooke 2001; Edbrooke & Brook 2009; Hayward 2017; Isaac 1996). Cherts of variable abundance, appearance and quality occur throughout this succession, within both sedimentary and volcanic formations (Moore 1977, 1983; Figure 1). The sedimentary cherts are predominantly of Triassic-Jurassic and Late Cretaceous to Eocene age, while the 'volcanic' cherts are mainly Miocene.

3.1. Sedimentary chert-bearing units

Sedimentary cherts are usually associated with fine-grained marine sedimentary rocks such as mudstone (or shale) and limestone, where the silica was largely derived from the dissolution of siliceous organisms such as radiolaria, diatoms, and sponges (spicules). Some well-bedded radiolarian cherts also occur within coarser-grained greywacke sequences, in places associated with submarine basaltic lava. The mode of occurrence, type, and stratigraphic context of sedimentary cherts considered in this study are summarised in Table 1.

3.1.1 Waipapa Terrane

The oldest rocks of Northland and Auckland, often loosely referred to as the 'greywacke basement', are variously mapped as Waipapa Terrane or Waipapa Group (Edbrooke 2001; Edbrooke & Brook 2009). These well-indurated, generally highly deformed sedimentary rocks (sandstone and argillite) include intercalated units of bedded chert which range in age from Late Permian to Jurassic. The bedded cherts are relatively common in places, particularly along the eastern Northland coast between Whangaroa and Whangarei as well as around parts of Auckland (Edbrooke 2001). The chert is generally reddish brown to greenish grey, usually highly fractured, and commonly contains radiolaria. Although no samples were included in this study, detailed petrographic and geochemical data have been obtained for a well-exposed section at Arrow Rocks near Whangaroa Harbour (Sporli et al. 2007).

3.1.2 Waiari Formation

This is an autochthonous lateral equivalent of the Whangai Formation, in part, and of latest Cretaceous to Paleocene age. The main outcrop is at Whatuwhiwhi on the northern side of Doubtless Bay, where it consists of dark grey to black siliceous mudstone with beds of similar-coloured chert (Isaac et al. 1988). Waiari chert has also been recorded at Mangonui and Albert Reefs (Isaac et al. 1994), in the Doubtless Bay area.

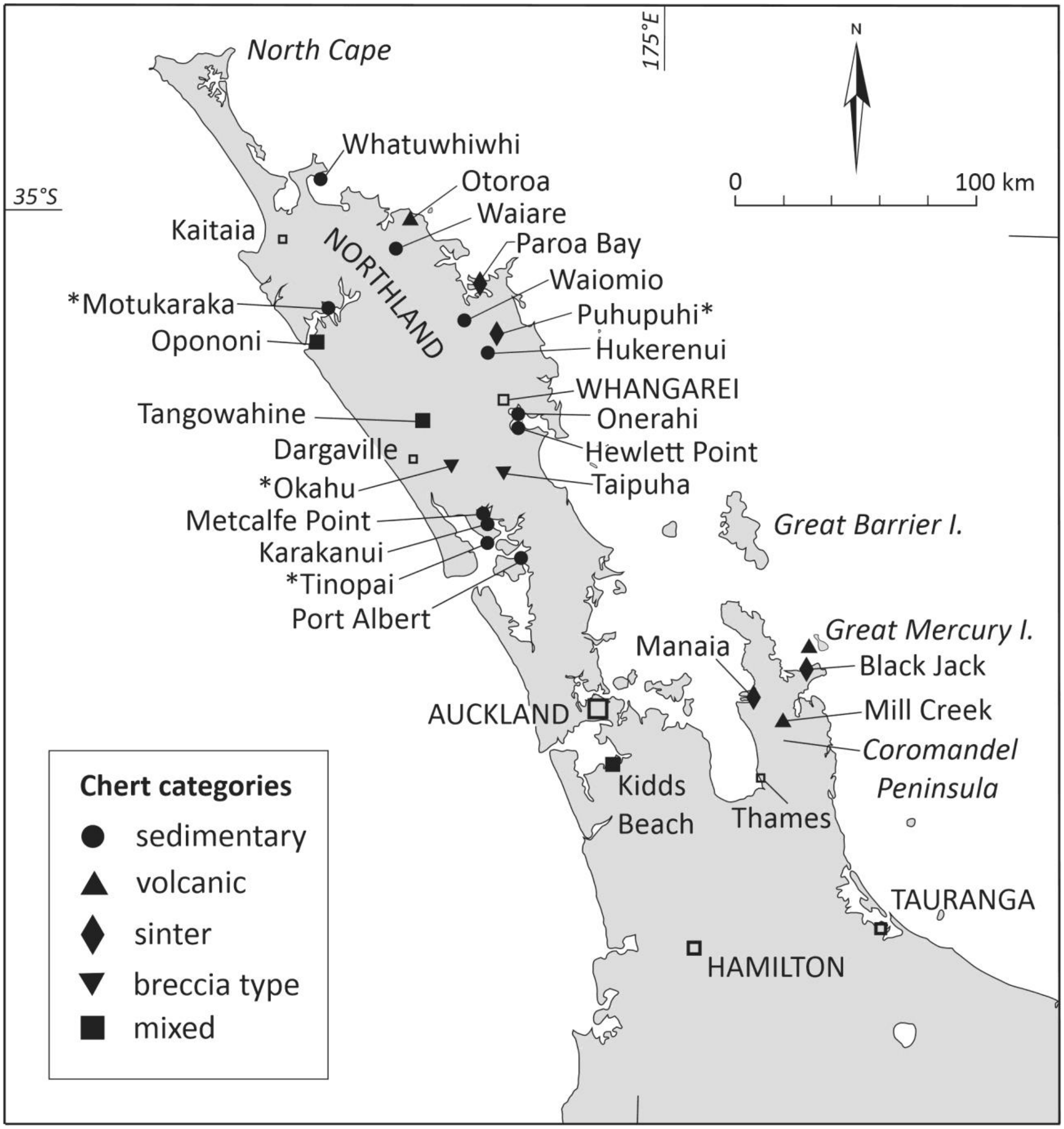

Figure 1: Map of the northern North Island showing the location of chert occurrences discussed or mentioned in the text. Those marked with an asterisk not considered in detail.

3.1.3 Mangakahia Complex

In Northland the Waipapa Terrane is generally overlain by a thick sequence of tectonically displaced (allochthonous) Cretaceous to early Miocene sedimentary rocks and volcanic massifs (Tangihua Complex), which make up the Northland Allochthon (Edbrooke & Brook 2009; Hayward 2017). Late Cretaceous to Eocene clastic sedimentary rocks within the Allochthon are grouped in the Mangakahia Complex, which includes at least two chert-bearing formations – the Hukerenui Mudstone and Whangai Formation. Most of the sedimentary chert in Northland is probably derived from these units.

Hukerenui Mudstone is a collective term for multi-coloured (green, grey, brown and red), typically non-calcareous mudstones, formerly known by a variety of names (e.g. Aponga Shale, Waiomio Complex). The mudstones range in age from Late Cretaceous to Eocene. Chert is common in the Waiomio and Hukerenui areas, where it occurs in situ as scattered nodules, and in the Waiare area near Kaeo (Figure 1). Green and brown 'flints' in the Pakaraka area, and white 'flint' concretions near Lake Omapere recorded by Skinner (1966), are probably also derived from the Hukerenui Mudstone (see also Brassey 1985). There appears to be a concentration of this type of chert in the area between Kaeo and Hukerenui.

Lenses and beds of chert have previously been recorded in the ***Whangai Formation*** at Rawene and Motukaraka Point in the Hokianga Harbour, within Paleocene calcareous mudstone (Isaac et al. 1994). However, the chert at Motukaraka Point is rare and closely fractured. Minor chert has also been reported at two localities in the Parengarenga Harbour, in the Far North (Hay 1983; Isaac et al. 1994; McKay 1894), but its quality is unknown.

3.1.4 Motatau Complex

The Eocene to earliest Miocene carbonate-rich sedimentary rocks of the Northland Allochthon are grouped in the Motatau Complex. It includes only one chert-bearing unit, the Mahurangi Limestone. Although this limestone is widespread in Northland, chert has been recorded only in the northern Kaipara Harbour area. At 'Metcalfe Point' (informal name), for example, the muddy limestone contains beds and concretions of fractured bluish to greenish grey chert (Arlidge 1955; pers obs). Similar chert has been found at Karakanui and Pahi, but not in situ, and 'flints' have been reported at various other localities in the northern Kaipara Harbour (Evans 1985).

3.1.5 Mélange

The Northland Allochthon also includes some extensive units of mélange, consisting of a highly sheared matrix of Mangakahia Complex mudstones with variable-sized blocks of different lithologies derived from the Mangakahia and Motatau complexes, igneous Tangihua Complex, and Waitemata Group (Edbrooke & Brook 2009). These mélange units, which are widespread in the Whangarei area and southern Northland, are a likely source of the 'breccia-type' chert (see below) as well as some mixed deposits recorded east of Dargaville (e.g. Curnow Rd, Okahu) and around the Kaipara Harbour.

Table 1. Mode of occurrence and stratigraphic context of sedimentary cherts.

Locality	Code	Mode of occurrence	Chert type	Geological unit
Whatuwhiwhi	WW	In situ	Waiari	Waiari Fmn
Waiare	WA	Detrital	Mangakahia	Mangakahia Complex
Opononi	OP	Detrital	various	Mangakahia Complex
Tangowahine	TW	Detrital	Mangakahia	Mangakahia Complex
Waiomio	WO	In situ	Mangakahia	Hukerenui Mudstone
Hukerenui	HK	In situ	Mangakahia	Hukerenui Mudstone
Onerahi *	OR	Detrital	Onerahi	Mangakahia Complex
Hewlett Point	HP	Detrital	various	Mangakahia Complex
Taipuha	TA	Detrital	various	melange
Metcalfe Point	ME	In situ + detrital	Mahurangi + Mangakahia	Melange + Mahurangi Limestone
Karakanui	KA	Detrital	Mangakahia + Mahurangi?	melange
Port Albert	PA	Detrital	Mangakahia	Mangakahia Complex

*Recorded quarry and working area

3.2. 'Volcanic' cherts and sinters

Chert of inorganic or hydrothermal origin also occurs in Northland, but is more common on Coromandel Peninsula where jasper is mainly associated with andesitic and rhyolitic volcanics. Additionally, both regions include a number of sinter deposits (Figure 1). In Northland, the **Otoroa chert** appears to comprise mainly of highly silicified wood, which has eroded out of laharic breccia deposits near the base of the andesitic Wairakau Volcanics (Hayward 1991). The sinter at **Paroa Bay**, originally recorded by Hector (1894), has not been studied. It consists of scattered large blocks and boulders on the hillside inland from Paroa Bay, resting on Triassic-Jurassic greywacke. Minor green chert has also been recorded within the volcanic Tangihua Complex, for example in the Mangakahia area in central Northland (Hay 1960: 49-50), but there do not appear to be any detailed descriptions of it. No samples were included in this study.

Other siliceous sinter deposits in Northland include the large, well-known deposit at Puhipuhi, north of Whangarei (Browne et al. 2002; Hampton 2002). Best and Merchant (1976: 108) also consider there was "workable sinter" at Maungataroto and Ngawha in Northland, though I have been unable to find any information on the former occurrence. There are some small deposits of sinter at Lake Omapere, about four kilometres northwest of Ngawha Springs (Browne et al. 2002; Pastars 2000), but it is opaline, brittle and not of artefact quality.

On Coromandel Peninsula, the **Manaia sinter** occurs as boulders up to one metre in diameter, containing abundant plant remains. It has not been studied and its geological relationships are uncertain, but is likely associated with the andesitic Beesons Island Volcanics. The main occurrence of chert on **Great Mercury Island** is a recorded quarry site (T10/346), within an outcrop of silicified breccia of the Coroglen Subgroup. Similar material is found as flakes along the nearby Huruhi Harbour. The sinter at **Black Jack,** formally known as the Waitaia Sinter, occurs as outcrops, blocks and boulders covering a considerable area between Kuaotunu and Otama Beach, on the Kuaotunu Peninsula (Newton 2000; Skinner 1976). It overlies lacustrine sediments and Jurassic greywacke, and is apparently overlain by andesitic volcanics. The chert at **Mill Creek**, much of which probably constitutes highly silicified wood, forms boulders up to 50 centimetres in diameter scattered over an area of at least two km^2. It is derived from breccias associated with the Carina Rock Ignimbrite of Whitianga Group (Moore and Wallace 2000; Skinner 1995). In addition to these occurrences, at least 18 deposits of siliceous sinter have been recorded between Whitianga and Paeroa, some of which have been studied in detail (Hamilton et al. 2019).

The **Kidds Beach** deposit, in Manukau Harbour, Auckland, consists of detrital chert reworked from conglomerate within the Pliocene Puketoka Formation. It is mostly composed of red-brown chert derived from the Waipapa Terrane, but some is almost certainly sinter, originating from the volcanic sequence on Coromandel Peninsula (Hayward et al. 2006). Puketoka conglomerate also outcrops near Maramarua (Battey 1949).

4. Sedimentary chert types

The recognition of different chert types in Northland is complicated by the stratigraphic complexity, tectonic disruption, and generally poor exposure of the main chert-bearing formations, and although samples were obtained in situ where possible, in many cases it was necessary to rely upon material from detrital deposits of less certain provenance. Nevertheless, five main types of sedimentary chert can be distinguished, based primarily on their colour, texture and geological context (Table 1, Figure 2). In general, these types reflect the composition and depositional environment of the original marine sediments and their subsequent burial history. The various types have been named according to either the stratigraphic unit they are associated with, or the particular geographic location where they are most common (e.g. Onerahi type). One type of chert is simply referred to as the 'breccia type' because of its distinctive breccia-like appearance and uncertainty over its origin.

The ***Waiari type*** is hard, dense and of good flake quality, and distinguished by its black to very dark grey colour and common presence of pyrite. It also displays parallel lamination on a millimetre scale, and contains rare burrows (Isaac et al. 1988).

The ***Onerahi type*** is predominantly yellow to yellowish brown in colour, but some is grey, red, reddish brown or colour banded (Figure 2B, 2C). Some pieces display bioturbation. The main deposit of this chert is at Onerahi, in Whangarei Harbour, where it occurs as concretions up to 50 centimetres in diameter. Very similar material has been found around the harbour on Limestone Island and at Hewlett Point, further north near Kamo and Hikurangi (pers obs), and also between Whangarei and Dargaville.

This chert is most likely derived from some part of the Mangakahia Complex. It does not appear to be associated with any of the sedimentary rocks that outcrop on the Onerahi peninsula, which range in age from Late Cretaceous to Oligocene (Evans and Hayward 1989), and the concretions have presumably eroded out either from a unit that is no longer exposed, or nearby mélange. Its age is therefore unknown. The occurrence at Onerahi is the only recorded pre-European chert 'quarry' in Northland (Frederickson 1990).

The ***Mangakahia type*** includes cherts from both the Hukerenui Mudstone and Whangai Formation, as no clear distinction can be made between them at present. Notably, the colour range of the chert found in the Whangai Formation at Motukaraka, in the Hokianga Harbour, is the same as that from Hukerenui (pers obs). Mangakahia chert is predominantly greenish grey, olive grey, bluish grey and greyish red. Bioturbation is evident in some samples (Figure 2A). Greenish varieties potentially could be confused with cherts of similar colour from the Waipapa Terrane or volcanic Tangihua Complex. This chert type may be more widely distributed than indicated, and possibly includes reported occurrences at Parengarenga Harbour in the Far North.

The ***Mahurangi type*** is predominantly light greenish grey to light olive grey, and weathers to a white or very light grey colour. The full colour range is unknown. It shows extensive bioturbation, and generally has a hackly fracture. Radiolaria are visible in some hand specimens under low magnification. The chert appears to be confined to the Kaipara Harbour area, and perhaps only the northern part of it.

The ***Breccia type*** is characterised by extensive veining (by chalcedony) which gives it a distinctive breccia-like appearance, and is commonly referred to as jasper-agate (Figure 2D). It is usually closely fractured, and only of moderate to poor flake quality. The chert is mainly yellowish brown to brown, although some is reddish brown. Boulders and cobbles of this chert are particularly common in southern Northland at places such as Taipuha, Ararua and Okahu (Curnow Road), and it has also been recorded at various localities in the northern Kaipara Harbour (Metcalfe Point, Karakanui, Port Albert), Whangarei Harbour (Onerahi, Hewlett Point), and at Tangowahine. Isolated pieces have been found further north at Opononi and Waiare. It might have a volcanic origin, based on the apparent lack of radiolaria, but appears to be associated mainly with mélanges and fault zones within sedimentary rocks of the Northland Allochthon, and therefore is currently regarded as a sedimentary chert.

At this stage, no formal types have been established for the volcanic cherts and sinters. However, some examples of these are illustrated in Figure 3.

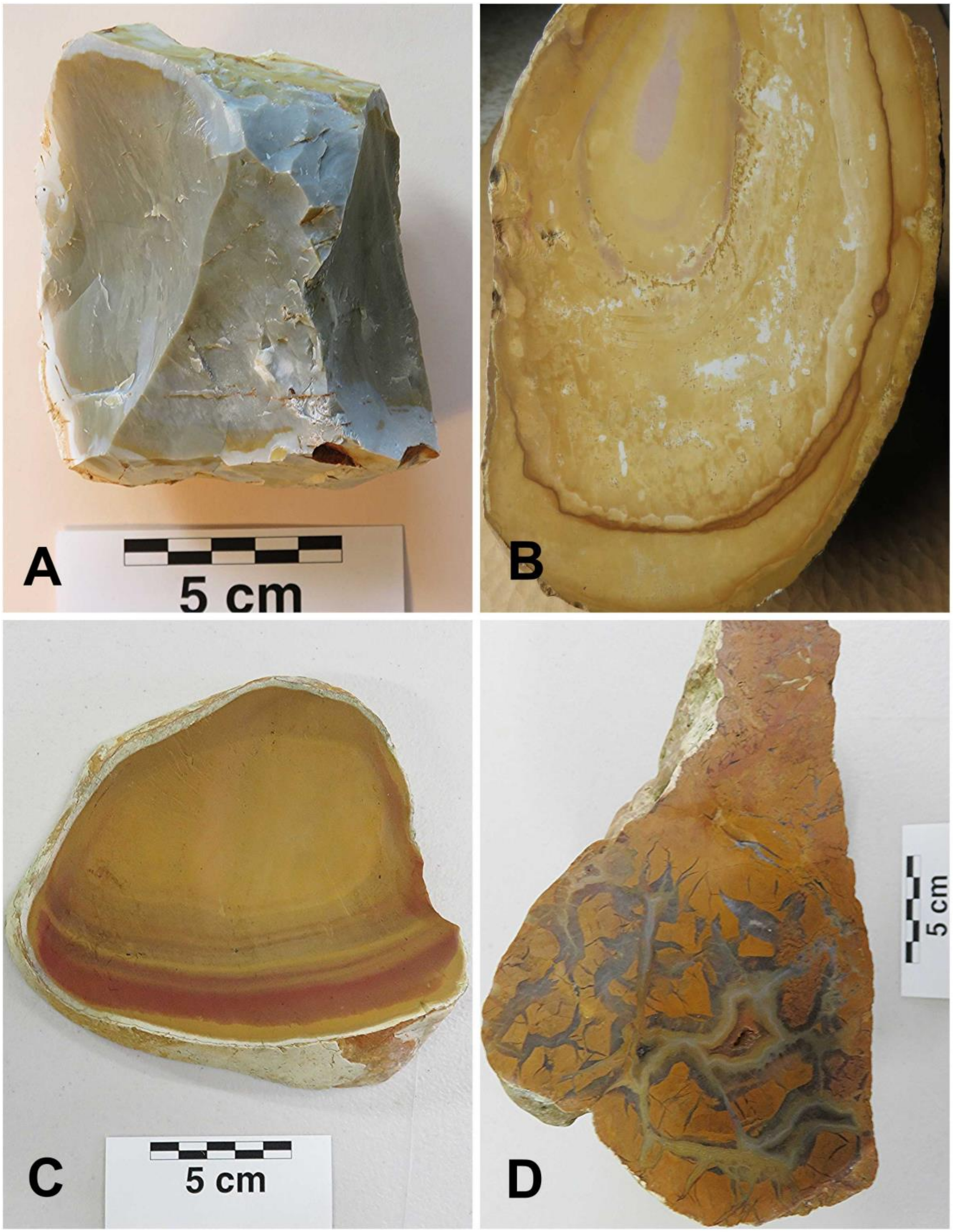

Figure 2: Selected examples of sedimentary chert types from Northland. A: Mangakahia type chert, Hukerenui. The faint 'blotchy' appearance on the broken surface (at left) is due to bioturbation of the original sediment. B: Concretion of Onerahi chert (23 cm diameter), Whangarei (*Gates Collection*). C: Colour banded Onerahi chert, Tangiteroria (*Fowke Collection*). D: Breccia-type chert, Tangiteroria (*Fowke Collection*), with fractures filled by chalcedony/agate.

5. Visual attributes

The main attributes that can be observed macroscopically, with a hand lens, or under a low-power binocular microscope (generally at 10X to 20X magnification) are colour, bioturbation and other sedimentary structures, veining, mineral content, microfossils, and plant remains. In this study, colour was determined with reference to the Munsell Soil Color Chart (2000 version), under natural light, and all samples were examined under a binocular microscope. In total, >160 samples were examined. Attributes of the cherts are summarised in Tables 2-5.

5.1. Sedimentary cherts (Tables 2, 3, Figure 2)

With the exception of the black Waiari chert, colour of the Northland cherts is highly variable, though most commonly grey to greenish grey, brown to yellow, and red (Table 2). In some deposits cherts are dominated by particular colours, such as red and grey at Waiare, yellow at Onerahi, and red to brown at Port Albert. Some samples are also strongly colour banded, with grey centres and yellow to white outer zones, due to weathering and staining by iron oxides (Figure 2). Overall, however, as indicated in Table 2, there appear to be no significant differences in the colour range among the sedimentary cherts of Northland.

Texturally, the cherts are all very fine grained (clay to silt grade). Very few contain any obvious sedimentary structures other than rare lamination, but bioturbation is usually common, ranging from faint to quite distinct, and in some cases including obvious oval-shaped burrows (Figure 2A). A few samples have a brecciated texture (e.g. Waiomio), or display other unusual textures like some samples from Opononi. Very thin veins of chalcedony or quartz are evident in samples from some localities, particularly Whatuwhiwhi (Waiari chert), Waiare and Port Albert. Extensive veining is characteristic of the breccia-type chert (Figure 2D).

The Waiari chert contains sparse to common pyrite crystals up to 2 mm across. This iron sulphide mineral was also observed in several of the samples from Tangowahine, in addition to small black or rusty spots of limonite, presumably resulting from the alteration of pyrite.

Fossil content of the cherts is largely restricted to radiolaria. These were observed in chert from all localities, and occur in at least 70% of the samples, ranging from rare to abundant. They are predominantly of spherical form (spumellarian type), and typically range in size from about 0.05 to 0.5 mm in diameter. Small conical radiolaria were also observed in some samples, along with a few possible agglutinated foraminifera. Small black flecks, apparently of organic matter, were evident in some cherts.

In order to identify the types of radiolaria present, five samples were processed at GNS Science, Lower Hutt in 2007, and examined by Dr Chris Hollis. These were selected from four different localities (Tangowahine, Waiare, Waiomio and Tinopai), and all contained visible radiolaria. However, no radiolarians were able to be extracted from three of the samples, another (Tinopai, TP1) contained indeterminable planktonic foraminifera and spumellarian radiolaria, and only one (Waiomio WO1, RD2341) yielded a well-preserved assemblage. Seven different species were identified in this sample, the majority having age ranges from Maastrichtian to Paleocene. Dr Hollis (report CJH-2007-02) commented that although all these species range into the Paleocene, the absence of Paleocene indicator species suggests a late Haumurian (Maastrichtian) age for the sample. This is consistent with the age of the Whangai Formation and Hukerenui Mudstone.

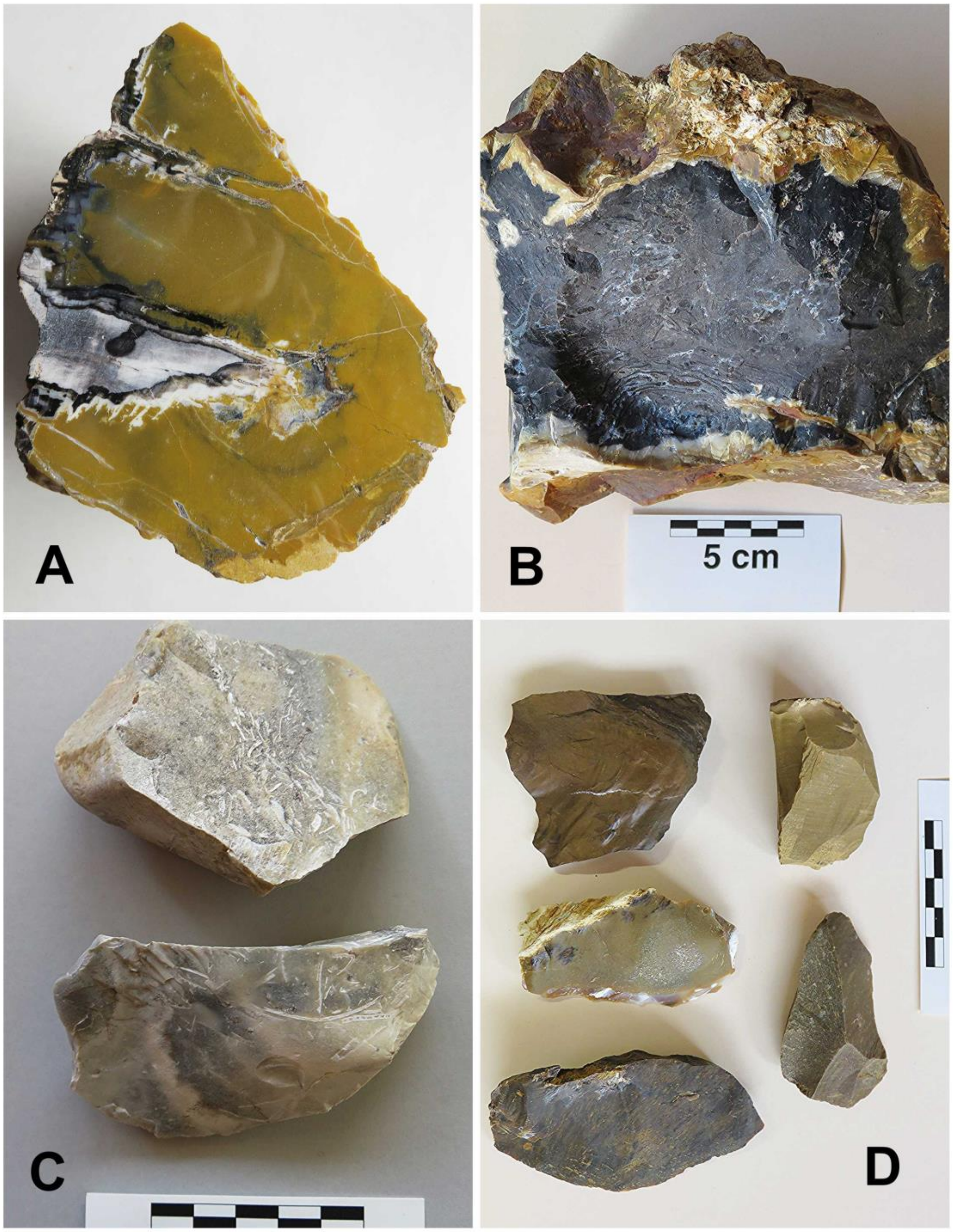

Figure 3: Selected examples of volcanic chert and sinter. A: Chert from Otoroa, enclosing a remnant of silicified wood (grey-white area; *Gates Collection*). B: Manaia sinter, containing abundant plant remains. C: Pieces of sinter from Black Jack with well-preserved plant remains. D: Selection of pieces from Mill Creek, showing the variation in colour and texture.

Table 2: Recorded colours of sedimentary cherts. More dominant colours indicated by bold symbols. See Table 1 for locality codes.

Locality	WW	WA	WO	HK	OP	TW	OR	HP	TP	ME	KA	PA
Black	**O**											
Dark grey	O				O	O		O	O			O
Grey		O			O				O	O	O	O
Light grey		**O**	O	O			O	O				
White					O			O				
Lt bluish grey		O										
Light green						O					O	
Greenish grey		O				O						
Lt greenish grey		O	O	O						O		
Olive grey			O			O				O		
Olive brown										O		O
Greyish brown									O			
Brown						O		O		O	O	O
Yellowish brown						O	O		O			**O**
Brownish yellow						O	O		O	O	O	O
Yellow		O					**O**					
Light yellow								O				
Reddish yellow							O					
Weak red		**O**	O	O	O		O					**O**
Reddish brown												**O**
Reddish grey		O										

Table 3: Visual attributes of sedimentary cherts from various localities in Northland.

Locality	Bioturbation	Lamination	Organic	Veins	Radiolaria	Minerals
Whatuwhiwhi	present		flecks	quartz	rare	pyrite
Waiare	present	rare	rare flecks	chalcedony	common	
Waiomio					sparse	
Hukerenui	present			chalcedony	sparse	
Opononi					common	
Tangowahine	rare	weak		chalcedony	present	pyrite, limonite
Onerahi	rare			chalcedony	sparse	
Hewletts Pt.			flecks		rare	
Taipuha				chalcedony	sparse	
Metcalfe Pt.	present		flecks		rare	
Karakanui	present		flecks		present	
Port Albert	present		flecks	chalcedony	sparse	quartz

5.2. 'Volcanic' cherts (Tables 4, 5, Figure 3)

The **Otoroa chert** is dense and of good flake quality. It is predominantly yellowish brown to olive brown, and rarely grey or red. Some includes remnants of silicified wood (Figure 3A). The sinter at **Paroa Bay** is very hard, dense and of excellent quality. It varies considerably in colour from white to various shades of brown and red. Some of the material contains plant remains.

The **Manaia sinter** is typically very dark grey with a yellowish-brown outer rind, or in some cases white or brown (Figure 3B). Plant remains are evident in most samples, including rounded stems up to 5 mm in diameter. Veins and vugs of quartz and chalcedony are also relatively common, and some samples contain patches of pyrite.

Chert from the quarry site on **Great Mercury Island** is predominantly yellowish brown. Samples typically have a clastic, sandy or breccia-like texture, and contain no obvious organic remains. Artefacts from nearby Huruhi Harbour are more variable in colour, ranging from yellowish brown to reddish brown and red. Yellowish brown samples tend to be fine grained, and some are weakly banded with a few vugs of quartz and chalcedony. These are similar to those from the quarry site.

Samples of sinter from **Black Jack** vary from white to very dark grey to yellowish-brown. They invariably contain sparse to abundant plant remains, including some with spherical cross-section and large cell structure, possibly reeds or sedges (Figure 3C). Most also contain vugs and veins of quartz and chalcedony, but pyrite is rare.

The **Mill Creek** chert is of high quality and predominantly yellowish brown to brown (Figure 3D). It is typically fine grained and faintly layered or banded, but some samples have a coarser breccia-like texture. Many also include thin veins of chalcedony. Organic remains were observed in only one sample, which included an elongate patch of silicified wood with remnant cell structure.

Apart from the dominant red-brown chert derived from the Waipapa Terrane, there are two other kinds of chert at **Kidds Beach** (Hayward et al. 2006; Figure 4). Some samples are yellowish brown to brownish yellow with a few thin chalcedony veins. They are all very similar and probably originated from the same source. The remainder are mostly dark to very dark grey, some with yellowish brown outer portions. All contain definite organic remains, including some stems with circular cross-sections. Most also contain a few vugs of chalcedony and quartz, and in one case common pyrite. These samples are very similar to those from Manaia, and almost certainly came from sinter deposits on Coromandel Peninsula.

Figure 4: Selected cobbles of 'volcanic' chert from Kidds Beach, Auckland. The sample at upper left is probably a sinter.

Table 4: Recorded colours of 'volcanic' cherts and sinters. More dominant colours indicated by bold symbol.

Locality	Otoroa	Paroa Bay	Kidds Beach	Manaia	Great Mercury	Black Jack	Mill Creek
Black			O				
Dark grey			O	**O**		O	
Grey						O	
Light grey	O			O		O	
White		O				O	
Lt bluish grey							
Light green							
Greenish grey							
Lt greenish grey							
Olive grey							
Olive brown	O						
Greyish brown							
Brown	O	O		O			**O**
Yellowish brown	**O**	O	O	**O**	**O**	O	**O**
Brownish yellow		O	O		O		
Yellow	O						
Light yellow							
Reddish yellow							
Red					**O**		
Weak red	O	O					
Reddish brown		O			O		
Reddish grey							

Table 5: Visual attributes of 'volcanic' cherts and sinters.

Locality	Code	Organic remains	Veins/vugs	Minerals
Otoroa	OT	common (wood)		
Paroa Bay	PB	sparse		
Kidds Beach	KB	none to common	chalcedony, quartz	pyrite
Manaia	MN	sparse to abundant	chalcedony, quartz	pyrite
Great Mercury	GM	none	chalcedony, quartz	
Black Jack	BJ	common to abundant	chalcedony, quartz	pyrite, hematite
Mill Creek	MC	rare (wood)	chalcedony, quartz	

6. Distinguishing sedimentary and volcanic cherts

Although it may prove difficult to identify a specific source for the chert in any analysis of artefact assemblages from the northern North Island, it should be possible to at least establish whether some of the chert is of sedimentary or volcanic origin and thereby limit the number of potential sources to be considered. Visual attributes that could be useful in making this distinction are indicated in Table 6. Perhaps the most useful criteria are the presence of bioturbation and radiolaria in sedimentary cherts, and of macroscopic plant remains (e.g. fossil reeds) in sinters and some volcanic cherts (wood cell structure). Colour may also be helpful in some cases, as few volcanic cherts appear to be greenish or bluish grey (Table 4).

Table 6: Distinguishing attributes of sedimentary and volcanic cherts.

Visual attributes	Sedimentary cherts	Volcanic cherts (including sinter)
Colour	Highly variable, but commonly grey, yellow-brown; less often greenish grey and red	Commonly yellow to brown, some red, grey and green
Bioturbation	Common	Absent
Organic remains	Rare flecks	Common in sinters (reeds etc.) and some cherts (remnant wood cell structure)
Radiolaria	Common	Absent
Veins	Generally sparse, except in Breccia type chert	Common, also quartz vugs
Minerals	Rare pyrite	Common pyrite

7. Exploitation

Only a small number of archaeological studies involving chert sources or analyses of chert artefact assemblages have so far been undertaken in the Northland and Auckland regions. The most significant is Fredericksen's (1990) examination of the only recorded chert 'quarry' and workshop at Onerahi, which revealed extensive working of the local material. Despite the quantity of chert that appears to have been worked at this site, limited information would suggest that it may not have been distributed much beyond the Whangarei Harbour area (Davidson 1981: 116).

Further north, an earlier study was undertaken by Brassey (1985) on various lithic materials from Pouerua, an extensive late period defended settlement inland from the Bay of Islands. In this case the large chert assemblage (>5600 pieces, weighing 15.8 kg) was divided into three groups based on visual attributes. These were then assigned to potential sources, with one group considered to originate from the Waipapa Terrane, and another from Cretaceous-Tertiary rocks.

For a much smaller assemblage (142 pieces) from Motutoa in the Hokianga Harbour, Prickett (1990) similarly divided the chert artefacts into separate categories, based primarily on colour. Some chert was believed to originate from the Waipapa Terrane, and other material from Cretaceous-Tertiary sediments. Whatever the original source, most appears to have been obtained from alluvial deposits.

A more recent analysis of artefacts from the early Tauroa Point site near Kaitaia included 730 items of chert (almost 8 kg), which constituted the most common lithic material (Phillipps et al. 2016). These were divided into three groups based on visual attributes, but about 85% could not be assigned to any particular source. At least some, however, likely came from the local beach. A second group of 22 artefacts with a "distinct fabric" was tentatively attributed to the volcanic Tangihua Complex in the nearby Herekino Gorge, and the third (80 artefacts) more confidently matched with samples from the Waiare area near Kaeo, some 70 km to the east.

The extent to which the various volcanic chert and sinter deposits were exploited during the prehistoric period is currently unknown. There is no definite indication that the **Otoroa** chert was exploited, though no detailed analyses of artefact assemblages from the area have been published. However, given the quality of the material, its use, at least locally, is very likely. Similarly, use of the **Paroa Bay** sinter is also probable, since flakes of it have been found along the shoreline. Chert from the **Kidds Beach** deposit in Manukau Harbour is considered to have been utilised at the NRD site in Mangere, a short distance to the north (Cruickshank 2011). There is no evidence that the **Manaia** sinter was exploited, but the material is very accessible and the stream it occurs in is named Te Mata (mata(a) = chert or obsidian). The quarry site T10/346 on **Great Mercury** is considered to have been the main source of chert artefacts found on the island (Site Record form), and the flakes exposed along the shoreline of Huruhi Harbour were presumably mostly derived from this site. The sinter at **Black Jack** is the likely source of at least some of the chert artefacts found at nearby Sarahs Gully (Davidson 2018), and much of the chert from the Opito Beach site further east has been identified as siliceous sinter (Boileau 1980). Additionally, one of the streams draining Black Jack hill is known as the Waimata. While there is no definitive evidence for use of the **Mill Creek** chert, the nearby hill is named Te Kiripaka (kiripaka = quartz), suggesting the occurrence was well known to local Māori. A few flakes and cores of very similar chert, some of which contain remnant wood cell structure (pers obs), have been found at several sites in the western Bay of Plenty.

8. Discussion

This study set out to provide some basic information on the geological context of chert occurrences in the northern North Island, to document different chert types, and to determine the variation in visual attributes, with the intention of encouraging the analysis of chert artefact assemblages. It is apparent, however, that the situation in Northland in particular is far more complex than initially thought, due in part to the abundance of material and its broad distribution, and that a more detailed study of cherts from the region will be required, possibly including the use of pXRF analysis. Nevertheless, a distinction can probably be made in at least some cases between sedimentary and volcanic cherts and sinters, using the criteria outlined.

One of the main problems lies in the similarity in the colour range of cherts from widely dispersed locations, making it difficult to determine, with any confidence, a specific source for a particular assemblage based on colour alone. In general, we can probably assume that most of the artefactual chert was procured from the closest, most accessible occurrence of useable material (e.g. Brassey 1985). But that was not necessarily the case. In Northland, for example, obsidian from different local sources was widely distributed across the region (Moore 2012), and while chert was probably regarded as being of lesser value than obsidian, higher quality material from certain sources may have been particularly prized and dispersed among distant communities.

Another aspect that has not been appreciated in the few analyses of chert assemblages undertaken so far is that some detrital sources include a mixture of material originating from two or more geological units, as clearly illustrated at Kidds Beach. What this means is that, potentially, all of the different types of chert found at a particular archaeological site could have been obtained from a single local deposit, as appears to have been the case at the NRD site at Auckland Airport (Cruickshank 2011). This emphasises the need for greater attention to be paid to the nature of detrital sources, the type of cortex, and to other visual attributes of the chert.

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The author confirms that the data supporting the findings of this study are available within the article.

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Conflicts of Interest

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