JOURNAL OF
Pacific Archaeology

– ARTICLE –

The green and the grey: use of visual attributes in the analysis of New Zealand obsidian artefact assemblages

Phillip R. Moore[1]*

[1]Peninsula Research, Bay of Plenty, New Zealand; ORCID https://orcid.org/0009-0001-2782-091X
*Corresponding author: peninres@xtra.co.nz

Abstract

There are about 20 known sources of artefact-quality obsidian in New Zealand, of which around half were extensively exploited by pre-European Māori. The visual attributes of the obsidians are described, and a procedure for identifying the original source of artefact material is outlined. Several case studies are presented to illustrate different aspects of the sourcing method, including its reliability. These, along with other studies, indicate that although some obsidian can be attributed to sources with >90% accuracy, the success rate is dependent upon the ability of the analyst and the particular mix of sources represented in any assemblage. Overall, the use of visual attributes combined with limited chemical analysis is considered the most effective means of sourcing larger obsidian artefact assemblages.

***Keywords*:** obsidian sourcing, visual attributes, New Zealand

To cite this article:
Moore, P.R. 2025. The green and the grey: use of visual attributes in the analysis of New Zealand obsidian artefact assemblages. Journal of Pacific Archaeology, 15(1): Article 5:1-25. DOI: https://doi.org/10.70460/jpa.v15i1.374

Submitted: 04/03/2025, Accepted 15/04/2025, First online 01/05/2025

The Journal of Pacific Archaeology is a peer-reviewed open access journal published by the New Zealand Archaeological Association

1. Introduction

The use of visual or physical attributes to identify the original source of obsidian artefacts recovered from archaeological sites has been employed in various parts of the world, for example in the western USA, Mesoamerica and the Mediterranean (e.g. Bettinger *et al.* 1984; Braswell *et al.* 1994; Braswell *et al.* 2000; Tykot 1996). In New Zealand its potential was first recognised by Green (1962), and in a subsequent paper (Green 1964) he demonstrated that differences in colour in transmitted light could be used to distinguish between obsidian from Mayor Island/Tūhua (green) and that from most other sources (grey). Experimentation with various analytical methods over the next few decades also revealed a need for more thorough sampling of obsidian sources (e.g. Brassey and Seelenfreund 1984; Moore 1983), which in turn led to a realisation that a wider range of macroscopic attributes could probably be used in the sourcing of artefacts, resulting in a more formalised procedure developed by Moore (1988). Although not without its drawbacks, which were readily acknowledged, this procedure has been applied to the analysis of obsidian assemblages by a number of practitioners, with reasonably reliable results (e.g. Cruickshank 2011; Furey 2002; Mosley and McCoy 2010; Neve *et al.* 1994).

With the introduction of pXRF analysis in New Zealand in 2008-9 it could have been assumed that because visual sourcing is supposedly too difficult and unreliable it would no longer be required. That has not proven to be the case. In this paper (an update of Moore 1988) I briefly describe the visual attributes of New Zealand obsidians, and demonstrate how these may be used in the identification of the original source of artefact material. Several case studies are also presented which illustrate different aspects of the sourcing method and its reliability.

2. Previous studies

Prior to 1988 the use of visual attributes in the analysis of obsidian assemblages in New Zealand generally consisted of a simple division into 'green' (Mayor Island) and 'other' (grey) varieties under transmitted light. Initially this was aimed at establishing a relative chronology, based on the belief that Mayor Island (Tūhua) in the Bay of Plenty was the first source to be discovered, and therefore older sites should contain a higher percentage of Mayor Island obsidian (Green 1964). While a subsequent statistical study revealed a general correlation between age and the proportion of Mayor Island obsidian nationally, it clearly showed that relative proportions were not a reliable indicator of the age of individual sites (Leach and de Souza 1979).

Green's (1964) original study involved nearly 2,800 obsidian flakes from 21 different sites, mainly in the Auckland region (Table 1). In the 1970s obsidian assemblages from other parts of the North Island were analysed by various workers, and by 1979 over 14,000 artefacts had been examined (Leach and de Souza 1979). Only a small number of these, from Palliser Bay, were subjected to chemical analysis (Leach and Anderson 1978). Since 1988 an additional 11,000+ artefacts were at least partially sourced following the procedure of Moore (1988), mostly supported by limited chemical analyses (Table 1). In total, visual attributes have been employed in determining the original source of more than 30,000 obsidian artefacts over the past 60 years. By comparison, about 4600 artefacts were analysed by pXRF between 2011 and 2018 (McCoy *et al.* 2018).

3. Obsidian sources

The use of visual attributes in the sourcing of obsidian artefacts requires a certain degree of familiarity with the source material. Many of the studies carried out in the past relied upon inadequate reference samples (e.g. Brassey and Seelenfreund 1984), and in the last 30 years in particular a concerted effort has been made to establish the variation in both the chemical composition and visual attributes of all obsidian sources (McAlister 2019; Moore 2011a, 2012a, 2012c, 2013).

The number of sources (and potential sources) recognised by archaeologists in New Zealand has changed significantly over the past 60 years, from nine in 1964 (Green 1964) to 18 in the early 1970s (Ward 1973, 1974), and generally about 20 since the late 1980s (Moore 1988; Seelenfreund and Bollong 1989). As many as 27 have been listed in certain publications (Neve *et al.* 1994; Sheppard 2004; Sheppard *et al.* 2011), but some of these were originally included only because of the possibility that deposits of non-flake quality obsidian may also contain better quality material (Moore 1988, 2020; Ward 1973), a fact that has been often overlooked. Most of these sources were located in the Rotorua area.

Present information, based on more detailed sampling and assessment of the evidence for exploitation (Moore 2011a, 2012a, 2013), suggests there are 21 to 23 sources (Figure 1), of which probably only about 13 were utilised to any extent (Moore 2024). These are here referred to as principal sources. Many of the others were exploited only on a small scale, if at all, and are classified as subordinate (or potential) sources. Obsidian does not appear to have been procured from some of the recorded sources either because of poor quality (e.g. Otoroa) or limited availability of material (e.g. Maratoto). Full information on the Poor Knights obsidian remains unpublished, and is not included here (but see Robinson 2016).

Table 1. Previous analyses of obsidian assemblages using visual attributes. Not all studies included.

LOCALITY	SITE	N	REFERENCE
Pre-1988			
Houhora	N03/59 (N06/4)	3150	Best 1975
Pouerua	6 sites	290*	Brassey 1985
Harataonga (Gt. Barrier I.)	N30/3, 4, 5	295	Law 1972
Auckland region	21 sites	2787	Green 1964
Westfield	R11/898	480	Furey 1986
Tokoroa	T16/1	510	Law 1973
Kawerau	V16/238	954	Furey 1983
Palliser Bay	N168/22	3525*	Leach & Anderson 1978
New Zealand	24 sites	5103	Leach & de Souza 1979
Sub-total		**17094**	
Post-1988			
North Cape	7 sites	247	Moore 1988
Aupouri Peninsula	72 sites	3490*	Moore & Coster (2015)
Houhora	N03/59	1127*	Furey 2002
Poor Knights Is.	various	541*	Moore (unpublished data)
Motutapu Island	R10/494	758	Ladefoged & Wallace 2010
Paeroa	Opita	167*	Neve *et al.* 1994
Kohika	V15/80	77*	Moore 2004
Ohiwa Harbour	W15/582	c.3500	Moore (unpublished data)
Maioro	R13/1	461*	Moore 2011b
Waikorea	R14/256, 284, 330	556*	Ritchie *et al.* 2009
Waikato coast	11 sites	780	Moore 2011b
Sub-total		**11704**	

*Assemblage partly analysed by chemical analysis

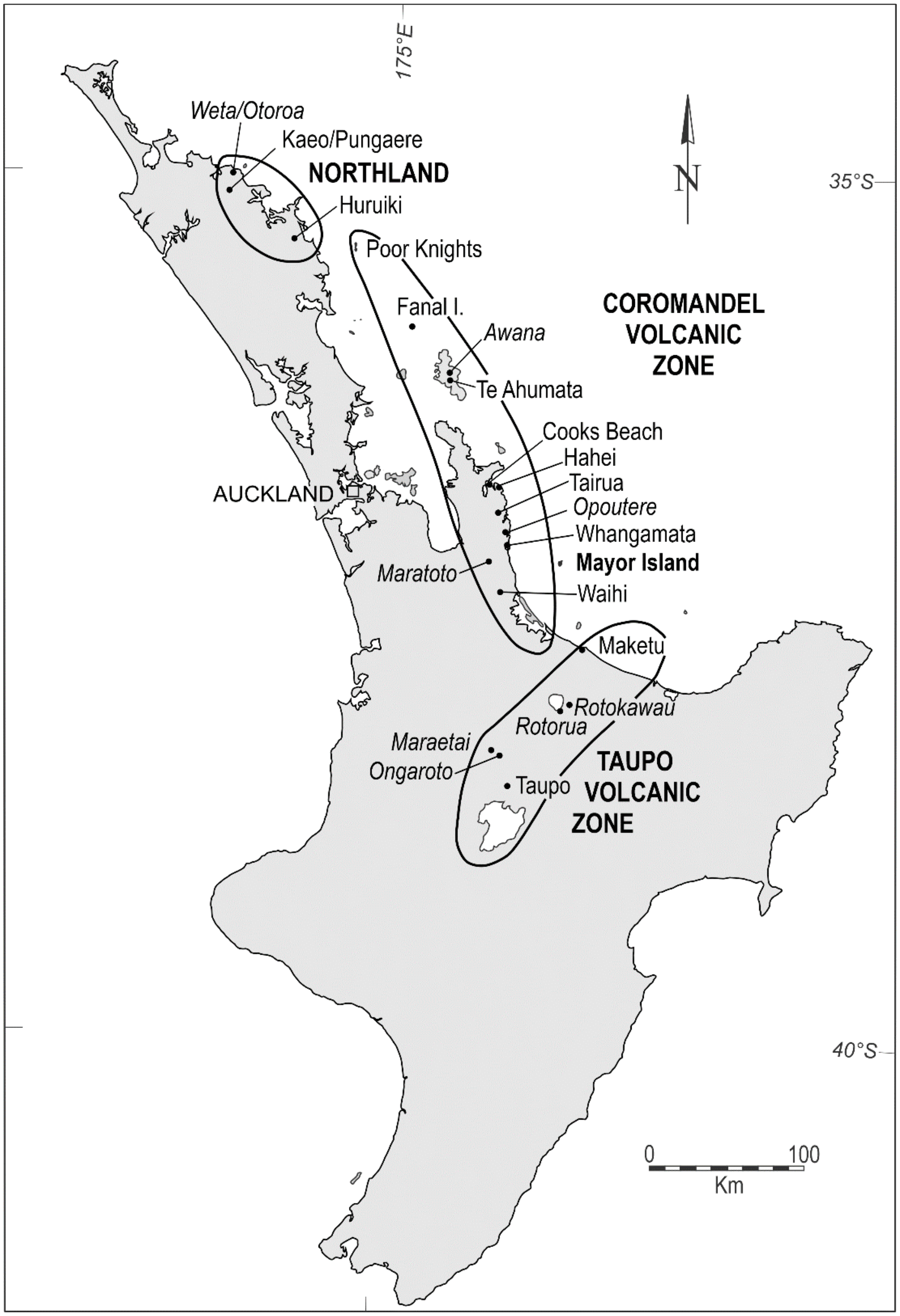

Figure 1. Obsidian sources and zones in the North Island of New Zealand (reproduced from Moore 2024). Principal sources in normal font, subordinate sources in italics. Maraetai and Ongaroto are referred to collectively as Whakamaru.

4. Visual attributes

Visual or physical attributes are those features of obsidian that are visible to the naked eye, with a hand lens, or under a low-powered binocular microscope. They include optical properties such as colour, translucency (or opacity) and lustre, and physical properties like fracture but, as the term is used here, exclude density. Some of the attributes are textural (e.g. flow banding, cortex), while others are mineralogical. Although most features can be identified macroscopically, use of low-power magnification (x10 to x30) is often an advantage.

There is a considerable range of visual attributes that have the potential to be useful in identifying sources, and these are briefly described here in approximate decreasing order of importance.

Colour is the most obvious and characteristic feature of obsidian, in both reflected and transmitted light. Under ordinary (reflected) light conditions obsidian generally appears black, but in transmitted light it may have a grey, green or brownish colour. Not all 'black' obsidian is strictly black, however, and shades of grey are quite common. Therefore, use of a standard colour chart (e.g. Munsell Soil Color Chart) in describing colour in reflected light may be appropriate in some cases, because opinions on what constitutes grey, dark grey and even black can vary considerably. This also applies to other colours such as 'red', which may range from true red to brown.

By examining flakes against a strong transmitted light source (fluorescent or halogen is preferable) it is usually possible to divide assemblages into different groups based on colour ('grey', 'green' and 'brown'). This process is much easier if the flakes are relatively thin, clean and not sand-blasted or water-worn. Thick pieces, and those with very poor translucency (i.e. almost opaque), may require a very strong light source. In determining colour in transmitted light it is important to use the same types of illumination for the entire assemblage, as colours can appear quite different under different light conditions (Booth *et al.* 2018). Light boxes are particularly useful for initial sorting into 'green' and 'grey' categories (Figure 2).

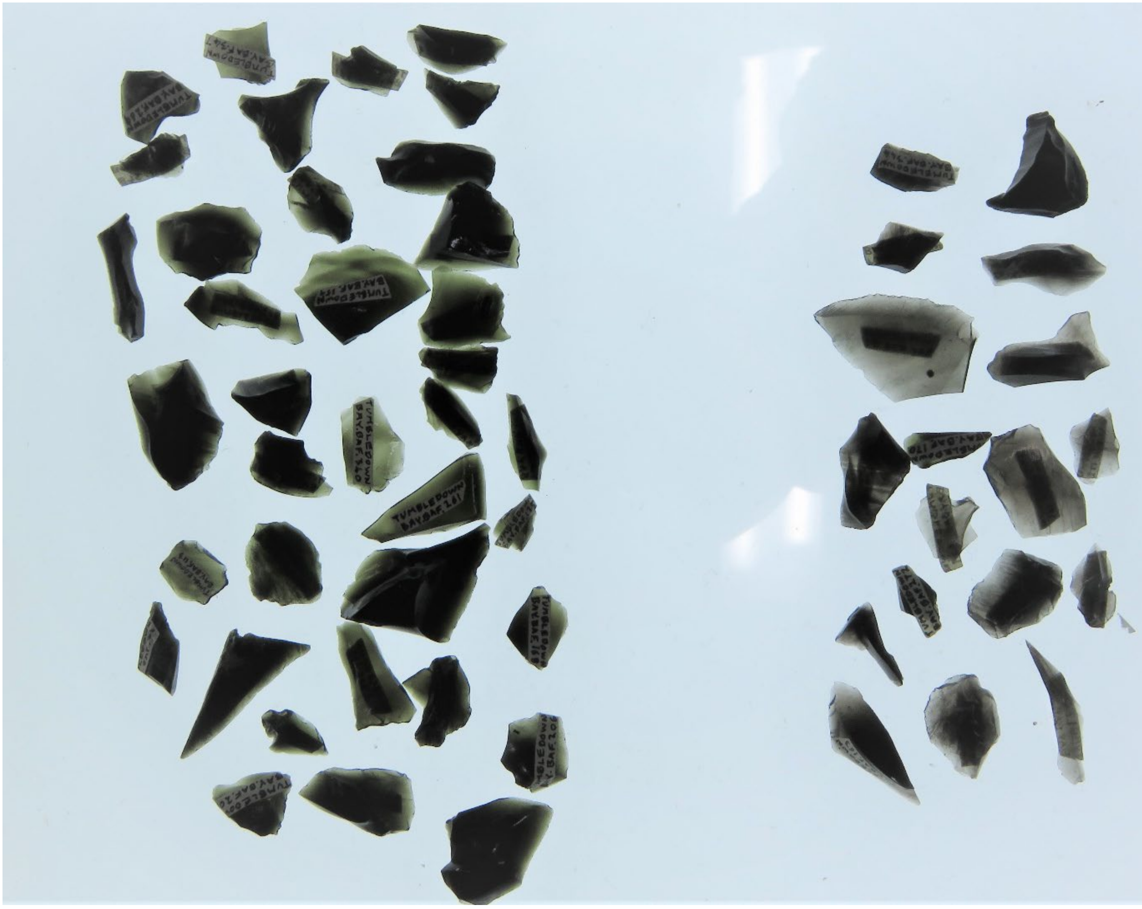

Figure 2. Sorting of 'green' Mayor Island (left) and 'grey' Taupo obsidian flakes on a lightbox. Note the good translucency of some of the 'grey' flakes. Assemblage from Tumbledown Bay, Banks Peninsula, Canterbury.

4.1. Translucency

The amount of light that will pass through obsidian (its translucency) is quite variable, and depends on a number of factors including thickness. While this needs to be taken into account when comparing artefacts with source samples, a clear distinction can be made between obsidian that is almost transparent and that which is virtually opaque. Only three descriptors are useful in referring to translucency: *Good* – can read newspaper lettering through a thin flake (i.e. virtually transparent), and may have a 'smoky' or brownish tinge; *Moderate* – turbid appearance, cannot read lettering or only with difficulty; *Poor* – limited light penetration, even through a thin edge. Obsidian which is almost opaque could be described as having very poor translucency.

In cases where the obsidian is strongly flow-banded, the degree of translucency can vary according to the orientation of the artefact in relation to the light source. Translucency is not dependent on quality, and may be good in obsidian containing abundant phenocrysts, and poor or very poor in some better-quality material.

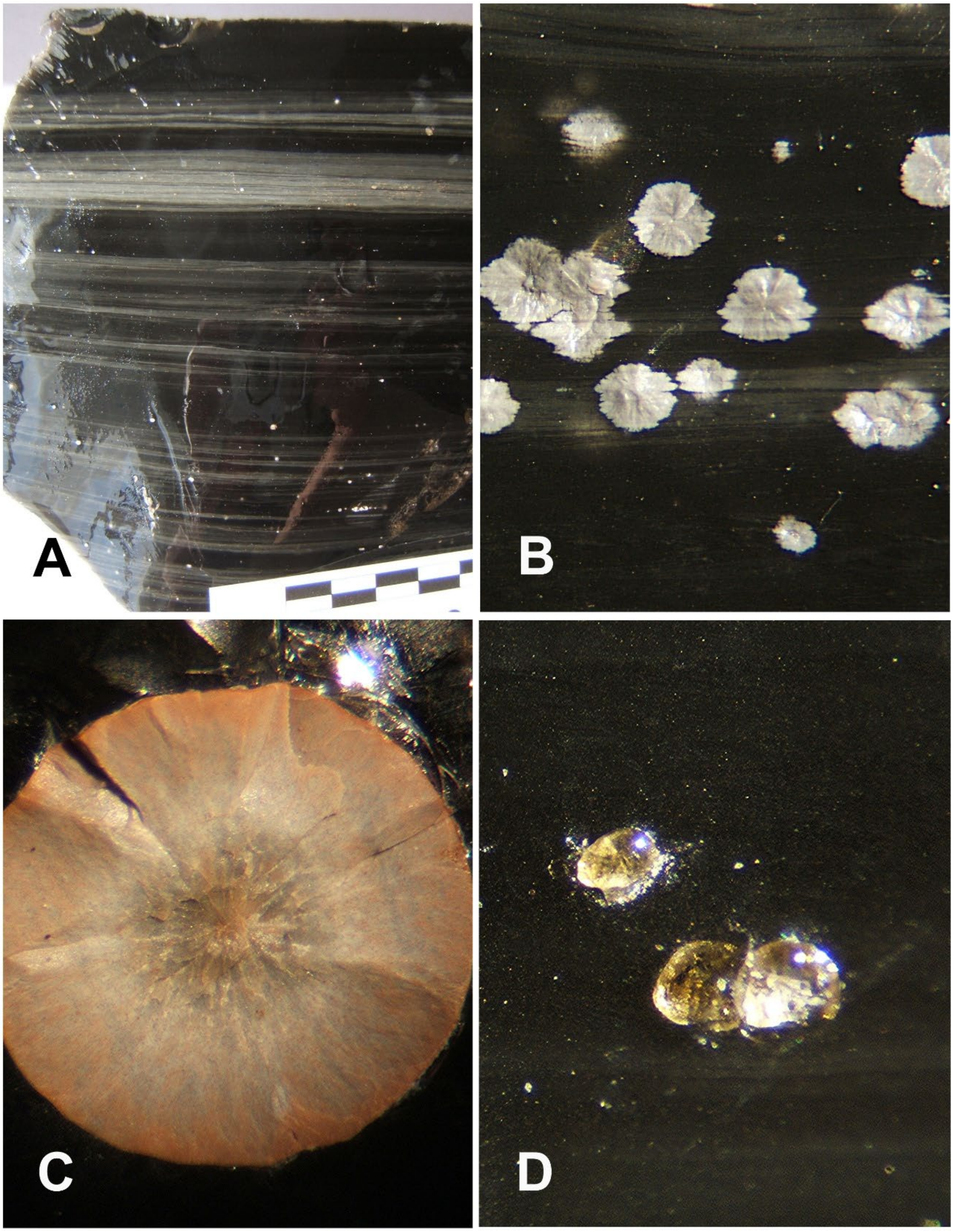

Figure 3. Selected visual features. A: strong flow-banding in Taupo obsidian; B: spherulites, Hahei; C: spherulite (5 mm diameter), Taupo; D: yellow globules (0.3-0.5 mm diameter), Fanal Island.

4.2. Flow banding

Obsidian commonly contains distinct layers or streaks of slightly different mineral composition or texture, formed while it was in a semi-molten state, which is termed flow-banding (Figure 3). The layers or bands are typically straight and parallel, but in some cases highly irregular or discontinuous. They may be highlighted by slight differences in colour, usually an alternation of black and dark grey, which is referred to as colour banding. The terms used to describe the nature of flow banding are very subjective, and only two are really applicable: *Strong* – distinct, generally parallel to sub-parallel bands, visible as well-defined lines in transmitted light, and usually reflected on weathered surfaces by a striated cortex; *Weak or wispy* – indistinct streaks or lenses, not strongly aligned.

4.3. Spherulites

Spherulites are small, generally spherical bodies composed of radiating fibrous crystals of feldspar and quartz or other forms of silica (Shelley 1993; Vernon 2004). They range from microscopic to >1 cm in diameter, but are typically 0.5-3 mm in size (Figure 3). Most are light to medium grey, though some are white or pink, and they may be concentrically zoned. In some cases spherulites form around cavities termed lithophysae (Shelley 1993).

Although spherulites can vary from rare to abundant, even within individual deposits, they may be of value in the identification of certain sources. For example, obsidian artefacts containing spherulites are very unlikely to have come from sources in which spherulites are, or believed to be, absent. However, some spherulites are very small, and use of a low powered microscope may be required to clearly distinguish them from phenocrysts (single crystals) or other inclusions.

4.4. Phenocrysts

Phenocrysts are the small crystalline minerals ('crystal inclusions') in obsidians. They are typically 0.5-2 mm in size, mostly irregular or rectangular in shape, and range from clear and glassy (quartz) to milky white (feldspar). Some obsidian may also contain black, tabular to needle-like crystals of hornblende or pyroxene, tiny hexagonal crystals of black biotite mica, or larger aggregates of phenocrysts (some of which may constitute rock fragments, termed xenocrysts). Because of their relatively small size, phenocrysts tend to be present in a high proportion of obsidian artefacts. High quality obsidian typically contains few if any phenocrysts, but they are often abundant in material with an imperfect conchoidal fracture or perlitic texture.

4.5. Globules

Globules are very small (typically <1mm diameter), rounded, clear glassy bodies, usually colourless or yellow-brown in colour and resembling tiny droplets of water or oil (Figure 3). They are apparently composed of quartz. Although rare in most obsidian, they are a distinctive feature of some sources (e.g. Fanal Island, Poor Knights, Ongaroto).

Fracture. Most obsidian has a perfect conchoidal fracture with characteristic smooth, shell-like concave or convex surfaces, but material with an imperfect or irregular fracture is also common. Perlitic obsidian (perlite) contains numerous closely-spaced semi-circular fractures which make it unsuitable for manufacture into useable tools (i.e. not flake quality).

4.6. Lustre

Lustre refers to the quality and intensity of light reflected from the surface of a substance. By definition obsidian usually has a vitreous lustre (like glass), but some is distinctly dull or waxy in appearance, and may be confused with pitchstone or even chert. Some pieces also display a silky or pearly sheen in strong light, caused by internal reflections off flow bands, stretched-out bubbles, or concentrations of crystallites.

4.7. Cortex

Cortex is the outer weathered, etched or water-worn natural surface. Much of the obsidian found in colluvial deposits on hillsides, or streams close to the parent source, has a rough, striated ('combed') or pitted cortex, due to etching by acidic groundwater. In contrast, alluvial pebbles and cobbles transported down rivers or streams, or along shorelines (littoral deposits), will show varying degrees of rounding caused by abrasion. The type of cortex on obsidian artefacts, therefore, can give a reasonably good indication of where or what kind of deposit the raw material originated from (in situ, colluvial, alluvial/littoral).

The proportion of flakes, pieces and cores in an assemblage that contain remnants of cortex may also provide some idea of procurement strategy. For example, the presence of water-worn cortex on obsidian from a source consisting primarily of in situ and colluvial material, as at Taupo, suggests that rounded cobbles from the nearby lake shore may have been preferred because of easier access and/or transportation. It is also possible to gain some information on the size of raw material procured (pebble, cobble or boulder) from the degree of curvature of the cortex surface. Size may be an indication of selection or of the nature of the source such as at Maketu, where only pebbles are available (Moore 2012c).

5. Analysis of obsidian assemblages

Visual attributes can be used in the analysis of obsidian assemblages in several ways: (1) as a simple screening technique, prior to chemical analysis, (2) to source an entire collection, without necessarily resorting to other methods, (3) provide an independent check on source assignments determined from chemical analysis, and (4) provide information on procurement. While the procedure works best on larger assemblages (N >100), single flakes can be sourced by this method. It is also not restricted by the size, shape or thickness of the artefacts, though tiny flakes or chips (debitage) may be very difficult to source.

The general characteristics of obsidian from the various sources are listed in Table 2. This provides the basis for construction of a simple flow chart, which enables potential sources with similar attributes to be more readily identified (Figure 4). For example, there are four or five sources consisting predominantly of 'grey' obsidian with good translucency, but by checking the chart to see whether they also contain spherulites, or few or abundant phenocrysts, some can be quickly eliminated from further consideration.

Clearly it is not necessary to follow this chart step-by-step, and in many cases the process can be short-cut. In using this procedure it is important to bear in mind that most analysed artefact assemblages appear to consist of obsidian from only three or four sources, with the bulk of the material usually derived from Mayor Island and one other principal source.

For procedures 1 and 2 the entire assemblage is initially sorted on the basis of colour in transmitted light into 'green', 'grey' and 'uncertain' groups; the latter may include pieces that are 'greenish grey', 'brown' or almost opaque. This can be a very quick process if the obsidian is clean and consists mainly of flakes, but cores and other artefacts with very poor translucency, thick cortex or a sand-blasted surface may require stronger illumination to establish their colour in transmitted light.

5.1. 'Green' obsidian

In general the 'green' obsidian can be attributed to Mayor Island, except in Northland where material from the Pungaere source forms a significant proportion of many assemblages (e.g. Booth *et al.* 2018; Furey 2002; Moore 2012b; Moore and Coster 2015). The Pungaere obsidian is distinctly more greyish in transmitted light, and also distinguished from Mayor Island material on the basis of its duller lustre and speckled texture (Table 3). In addition, many pieces from this source have remnants of rough to slightly water-worn cortex, whereas cortex (invariably smooth and water-worn) is extremely rare on Mayor Island obsidian (Moore 2015). Although Waihi obsidian was previously considered to be green-grey in transmitted light (Moore 1988), further examination of samples indicates that it is distinctly brownish (olive brown) compared to Mayor Island and Pungaere material. It is also distinguished by its poor translucency, olive grey colour (in reflected light) and strong flow banding. A small quantity of the obsidian from the Awana source is green in both reflected and transmitted light, but is not of flake quality.

5.2. 'Grey' obsidian

Once all 'green' obsidian (if any) has been separated out, a decision is then required as to whether the remaining 'grey' material is analysed solely by chemical analysis (procedure 1), by visual examination alone (procedure 2), or a combination of these. This will depend on the size of the collection, the level of certainty required in source allocation, and other factors such as time, cost and instrument availability. For large assemblages, consisting of hundreds of pieces, chemical analysis of the entire 'grey' group might be unrealistic, and visual sourcing with limited back-up from chemical methods may be more appropriate (e.g. Cruickshank 2011; Moore and Coster 2015; Moore *et al.* forthcoming).

Sourcing of the 'grey' obsidian by visual examination involves first splitting it into sub-groups based on one or more criteria, which could be translucency, abundance of phenocrysts, presence/absence of spherulites, type of cortex (e.g. rough or smooth/water-worn), or a combination of these. Degree of translucency is a relatively quick means of dividing up assemblages, since it can be done at the same time as the initial sort into 'green' and 'grey' categories. Obsidian with good translucency (and only rare phenocrysts) is typical of the Te Ahumata and Taupo sources, whereas poor translucency is more characteristic of (but not restricted to) sources such as Huruiki, Hahei and Tairua (Table 2, Figure 4).

Table 2. Visual attributes of obsidian sources (excluding the Poor Knights and Opoutere). Maraetai and Ongaroto are referred to collectively as Whakamaru (Moore 2012c).

Source	Colour (reflected)	Colour (transmitted)	Translucency	Spherulites	Phenocrysts	Globules
Otoroa #	Black-dark grey	Grey	Good	None	Abundant	Common
Pungaere	Black	Olive grey	Mod-poor	None	Rare	None
Huruiki	Black, dark grey	Grey, (brown)	Mod-poor	Rare	Rare-sparse	Rare
Fanal Island	Black-grey	Grey	Good-poor	None	Abundant	Common
Awana #	Black-dark grey	Grey, (green)	Mod-poor	None	Sparse-ab.	None
Te Ahumata	Black, grey	Grey, (brown)	Good	Sparse	Rare	Rare
Cooks Beach	Black-dark grey	Grey, (brown)	Mod-poor	Common	Rare-comm.	Rare
Hahei	Black	Grey	Poor	Common	Rare-comm.	Rare
Tairua	Black-dark grey	Grey	Poor	Rare-ab.	Common	Rare
Whangamata	Black-dark grey	Grey, (brown)	Good-poor	Rare-ab.	Rare	Rare
Maratoto #	Black	Grey	Very good	None	Uncommon	None
Waihi	Dark olive grey	Olive brown	Mod-poor	Rare	Rare	None
Mayor Island	Black	Olive green	Good-mod	None	Rare	None
Maketu	Black-dark grey	Grey	Poor	Rare-ab.	Sparse	None?
Rotokawau	Dark grey-black, red-brown	Grey	Mod-poor	Common	Sparse-common	Rare
Rotorua ¶	Black, red-brown	Grey		Sparse?		Common
Maraetai #	Black-dark grey	Grey	Good-poor	Common	Common	Sparse
Ongaroto #	Black-dark grey	Grey	Good-poor	Common	Common	Common
Taupo	Black, grey, red-brown	Grey, (red)	Mod-good	Rare-comm.	Rare-sparse	Rare

‡Colours in brackets are rare; # Not known to have been exploited, or only locally; ¶ Insufficient samples were available to properly characterise the Rotorua source, which is now restricted to Whakarewarewa (Moore 2020).

Table 3. Characteristics of ‘green’ obsidian

Attribute	Mayor Island	Pungaere
Colour (transmitted light)	Olive green	Olive grey
Lustre	Vitreous	Dull, speckled
Translucency	Generally good	Moderate
Flow banding	Weak to strong	Generally weak
Cortex	Smooth water-worn (very rare)	Rough to slightly water-worn (common)
Other	Vesicles	Xenoliths

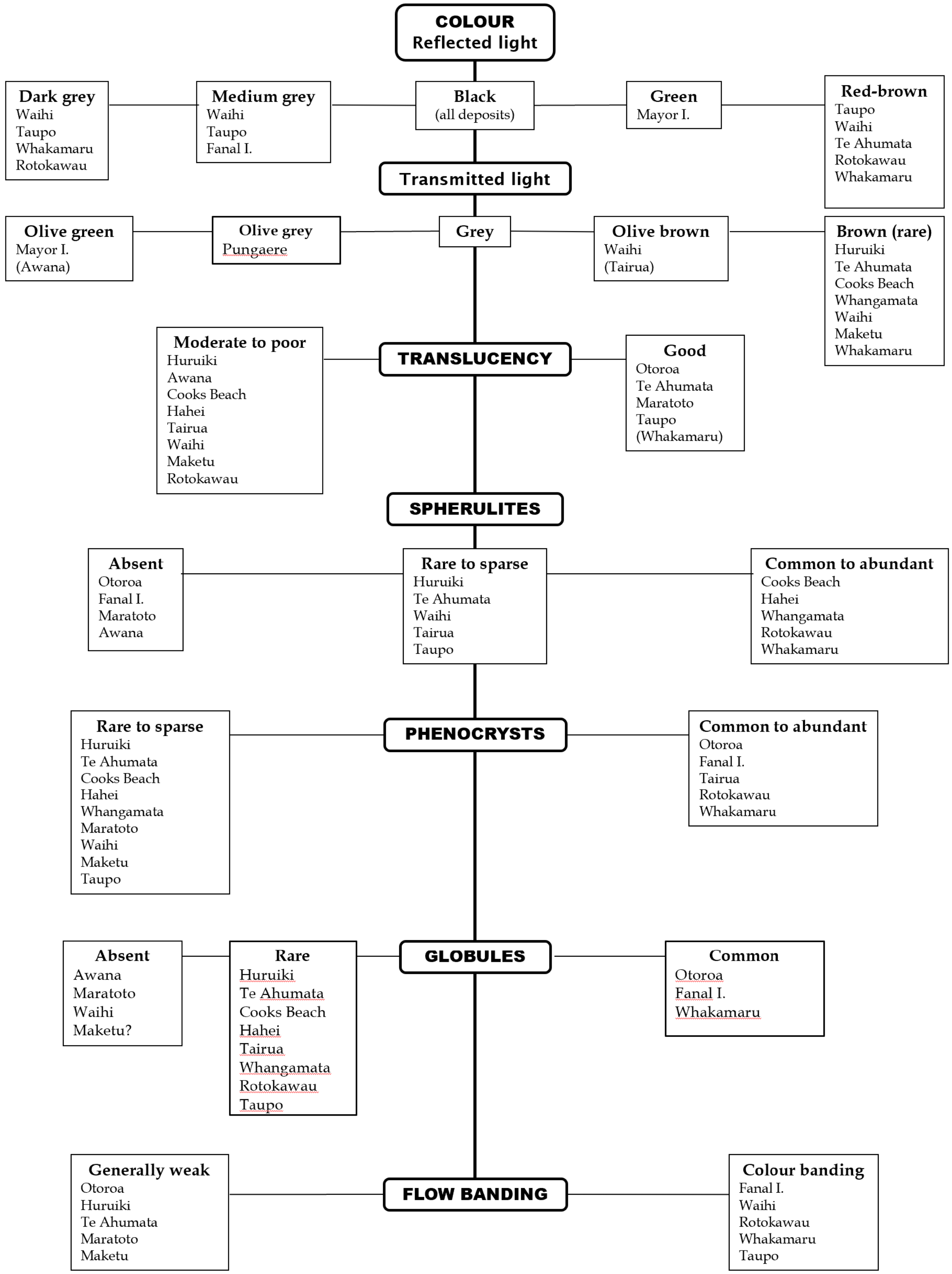

Figure 4. Flow chart for identifying obsidian sources (excluding Poor Knights, Rotorua and Opoutere)

Spherulites were earlier thought to be absent from all Northland sources (Moore 1988), but more detailed sampling has revealed that Huruiki obsidian does contain sparse spherulites. They are certainly absent, however, from Otoroa, Fanal, Awana and Maratoto material, and rare in Te Ahumata obsidian. The relative abundance of phenocrysts may also be useful in identifying potential sources. They are common in Fanal and Whakamaru material, and abundant in Otoroa obsidian (which is of marginal flake quality). Recent studies have also indicated that glassy globules may be of value in distinguishing between sources characterised by common phenocrysts. They are particularly common in obsidian from Fanal Island (yellow-brown) and Ongaroto (uncoloured), and sparse to abundant in Poor Knights material (Moore and Coster 2015), but generally rare elsewhere. Other criteria, such as flow banding may be of use in some cases. Strong flow banding for instance is typical of obsidian from Fanal Island, Cooks Beach, Rotokawau and Whakamaru. Cortex has proved to be an important factor in at least one study (Moore 2004).

It may be possible to tentatively assign sources to some of the sub-groups. There will be cases, however, where the 'grey' assemblage consists of obsidian from several different sources with very similar visual attributes, making it extremely difficult to identify a specific source with any degree of confidence. The main 'culprits' are likely to be Huruiki, Cooks Beach, Hahei, Whangamata and Rotokawau, where a significant proportion of the obsidian has moderate to poor translucency and contains spherulites, though Huruiki material may be distinguished on the basis of its yellowish globules (if present). Greater certainty could be achieved by direct comparisons between the artefacts and reference samples (if available).

The third procedure – use of visual attributes to check the source assignments determined from earlier chemical analysis – has rarely been employed, even in cases where colour or other characteristics of analysed artefacts have differed markedly from those of the indicated source (e.g. Leach and Anderson 1978), or the source was not definitely known to have been exploited. For most studies where assemblages were analysed solely by chemical methods, there has been no independent check on the reliability of the results (e.g. Seelenfreund and Bollong 1989).

5.3. Red and brown obsidian

Obsidian that is red to brown in reflected light is rare. The main occurrence of flake quality red-brown material is at Taupo, but small quantities have also been recorded at Whakamaru, Rotokawau and Rotorua in the central North Island (Moore 2012c, 2020; Ward 1973), Waihi (Moore & Coster 1989), Te Ahumata on Great Barrier Island (Moore 2013), and at Otoroa in Northland (Moore 1988, 2012a). Purangi, near Cooks Beach, has also been regarded as a source of red obsidian in the past, but this is doubtful (Moore 1983, 2013). So far, no reliable criteria for distinguishing between the red-brown obsidians from these sources have been identified.

Several sources also contain a small quantity of obsidian that is brown in transmitted light, including Waihi, Whangamata, Cooks Beach, Te Ahumata and Huruiki (Moore 2012a, 2013). A few flakes of such material have been recorded in some artefact assemblages (e.g. Cruickshank 2011; Moore 1999).

5.4. Intra-source variability

The main problem with sourcing of the 'grey' obsidian is the intra-source variation in visual attributes, which has become more apparent with improved sampling of the deposits. However, this does not mean that none of the 'grey' obsidian can be reliably sourced, simply that there is a need to be aware of such variation and to allow for it accordingly. In fact, some variants are quite distinctive (as documented above), and their presence may provide an indication of where the bulk of the obsidian in an assemblage is from.

In the case of the Taupo source, for example, four main types or variants are recognised (Moore 2011a). Black obsidian (Type 1) predominates, and includes three distinct sub-types: black with moderate to good translucency (Type 1A), black streaky (Type 1B), and black with poor translucency (Type 1C). The other more obvious types are grey (Type 2), banded (Type 3) and red-brown (Type 4). Since black material with moderate to good translucency (Type 1A) is by far the most abundant, it is likely to be the dominant variant represented in artefact assemblages. To confirm this, artefact collections from the nearby cave shelters of Whakamoenga and Waihora were partially re-examined and classified according to the different variants recognised within the source material. Both assemblages are dominated by 'typical' Taupo obsidian (Type 1A) and contain fairly similar proportions of the black streaky variety (Type 1B), although banded material (Type 3) would appear to be more common at Waihora. As expected, Type 1C (poor translucency), Type 2 (grey) and Type 4 (red-brown) are rare at both sites. Overall, black obsidian makes up at least 75% of the Whakamoenga assemblage and a minimum 70% of that from Waihora.

This information provides a better indication of the relative abundance of the different variants than could be achieved by systematic sampling of the source area. Assuming no preferential selection of a particular type, it can therefore be used as a benchmark for comparisons with other assemblages. Perhaps more importantly, it suggests that a significant proportion of the obsidian recovered from the Whakamoenga and Waihora cave shelters was procured from the same part of the source area, namely Whangamata Bay. This is supported by the relatively high proportion (>22-28%) of artefacts with water-worn cortex at both sites.

6. Reliability

How reliable the source assignments made on the basis of visual examination are is obviously a critical question, and this is perhaps best answered through a number of case studies (see Appendix A). These particular studies were selected to illustrate various aspects of the process: the replication of results (by the same analyst), differences between analysts, and comparisons with chemical methods. They demonstrate that very similar results can be achieved by different practitioners, and there is generally good agreement with source attributions made on the basis of chemical analyses. They also illustrate that reasonably reliable results can be obtained by practitioners with limited or no prior experience in obsidian sourcing. Other studies that provide information on reliability include those by Moore and Coster (2015) and Mosley and McCoy (2010).

One other advantage of visual sourcing is that entire artefact assemblages can be analysed, including very small flakes, thus providing more reliable data on the relative proportions of obsidian from different sources, at the very least for Mayor Island and 'grey' material. This is not the case for most pXRF analyses where only artefacts of a certain size are selected (generally >10mm), and those that are too small, too thin, or of inconvenient shape are usually rejected, which means that a significant proportion may not be analysed at all. In the study by Sheppard *et al.* (2011), for example, the number selected for pXRF analysis constituted only 60% (n = 565) of the total assemblage, creating uncertainty about where the remaining 40% of the obsidian originated from, and in what proportions (Moore 2012d). In some pXRF studies the size of the original assemblage was simply not recorded.

7. Discussion

As with any method of analysis, the use of visual attributes in identifying the original source of archaeological obsidians has its advantages and disadvantages. One of the main objections to using such a procedure is that it requires a certain degree of familiarity with the various features of obsidian, and (preferably) access to appropriate reference material (e.g. Neve *et al.* 1994). In the sourcing of 'grey' obsidian that may indeed be the case, but it does not require such knowledge or reference samples to simply divide artefact assemblages into 'green' and 'grey' (and possibly 'brown') groups, only a suitable light source. Another criticism is that it is difficult to objectively assess the quality or reliability of the results, particularly when obtained by different analysts (Sheppard *et al.* 2011: 45). That is a valid point, although it can be largely overcome by the chemical analysis of representative samples from a collection, as originally advocated by Moore (1988). However, despite such concerns, some researchers have considered it quite acceptable to use the results of visual sourcing undertaken by themselves or others (e.g. Brown and Pitman 2019; Lawrence *et al.* 2014; Walter *et al.* 2010).

It is evident from the case studies reviewed in this paper that the reliability of source assignments based on visual attributes will depend upon various factors such as the size and nature of the assemblage, condition of the artefacts, the number and type of sources represented, and experience of the analyst. Researchers elsewhere have reached much the same conclusions. For example, in re-assessing the reliability of visual sourcing of obsidian assemblages from the western Great Basin, Psota (1990) found that although some analysts may only achieve correct source assignments of <50%, the results generally improved with increased experience. The success rate also depended on the particular mix of sources involved, as previously noted by Bettinger *et al.* (1984). Similar studies undertaken in Mesoamerica, however, have demonstrated that remarkably consistent and accurate results (typically >90%) can be obtained by experienced lithic analysts, albeit when only a small number of sources are involved (Braswell *et al.* 1994; Braswell *et al.* 2000).

While it is acknowledged that the errors associated with visual sourcing will, in many cases, be greater than those of chemical analysis, this needs to weighed against the advantages of visual examination, including the low cost, availability, and ability to deal with large assemblages. Sufficient studies have now been carried out to indicate that in most studies >90% (and in ideal situations 100%) of the 'green' obsidian can be correctly attributed to Mayor Island, even in Northland where there is some potential for confusion with the greenish grey Pungaere material (Booth *et al.* 2018; Moore 2012a). Although the 'grey' obsidian remains more difficult to source, it would appear that most practitioners are capable of distinguishing different groups within the 'grey' category, and attributing potential sources to at least some of those groups. Even if, in the worst-case scenario, none of the 'grey' material could be confidently assigned to a source, the recognition of groups or types with different visual attributes still constitutes an important step in the sourcing process. If it reduces the number of samples required for chemical analysis, or provides support for source assignments from pXRF analysis, then it can be considered of value.

Funding

This research received no external funding.

Data Availability Statement.

Data sharing not applicable – no new data generated.

Partnerships

This research did not use any primary data from Indigenous contexts.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

Conceptualization, P.R.M. methodology, P.R.M.; P.R.M.; investigation, P.R.M.; writing—original draft preparation, P.R.M.; writing—review and editing, P.R.M.; visualization, P.R.M.

Acknowledgements

This paper was originally prepared to mark the 50th anniversary of the first significant publication on obsidian in New Zealand, by the late Roger Green in March 1962. I am indebted to Roger for his advice and encouragement. My thanks also to two unknown reviewers for their helpful comments.

Appendix A: Case Studies

Case 1: North Cape

The replication of results is a fundamental test of the reliability of any analytical method. So, would the re-analysis of an obsidian assemblage produce similar results if it was analysed by the same person after a significant period of time?

This was tested on a total of 248 pieces of obsidian collected from seven separate sites in the North Cape area. The original analysis was carried out by the author in 1987, and presented as an example of how visual attributes could be used in obsidian sourcing (Moore 1988). The assemblages from each site were separated into three categories based on colour in transmitted light: olive green (Mayor Island), olive grey (Pungaere), and grey. A small number, all greenish, were unable to be positively assigned to either of the first two groups and therefore classified as 'uncertain'. Although the grey obsidian could not be sourced at that time, it was considered likely to have come from Coromandel Peninsula and/or Huruiki deposits. Subsequent pXRF analysis has indicated the obsidian originated from Hahei, Cooks Beach and Huruiki (unpublished data).

The same categories were distinguished in 2011, and comparison of the two sets of results is shown in Table A1. The proportion attributed to Mayor Island is about the same, and the main differences are in the number of pieces assigned to the Pungaere source and the 'uncertain' group (which reduces from 12 to 5), reflecting improved knowledge of the Pungaere source material. There was no change in the proportion of 'grey' material. Overall, the differences between the two analyses are relatively small.

Table A1. Re-analysis of North Cape obsidian assemblages

SOURCE	**N**	**Mayor Island**			**Pungaere**			**Uncertain**		**Grey**	
SITE		1988	2011	Diff.	1988	2011	Diff.	1988	2011	1988	2011
Waikuku 1	6	2	2	0	4	4	0	0	0	0	0
Waikuku 2	22	14	12	2	0	3	3	0	0	7	7
Waikuku 3	28	10	10	0	13	15	2	2	0	3	3
Waikuku 4	46	32	29	3	9	9	0	0	3	5	5
Sub-total	102	58	53	5	26	31	5	2	3	15	15
Whareana 1	55	28	28	0	24	26	2	2	0	1	1
Whareana 2	75	7	10	3	61	62	1	6	2	1	1
Whareana 3	16	4	4	0	10	12	2	2	0	0	0
Sub-total	146	39	42	3	95	100	5	10	2	2	2
TOTAL	**248**	**97**	**95**	**2**	**121**	**131**	**10**	**12**	**5**	**17**	**17**

Case 2: Houhora

In this case the results of sourcing by chemical analysis were subsequently checked by visual examination (by two different practitioners), and a comparison of the results is shown in Table A2 (see also Moore 2012d). The initial analysis, by EDXRF, involved 300 randomly selected flakes from the early Houhora site in Northland, which indicated that 64% were most likely from Mayor Island, 18 per cent from Northland (probably Pungaere), three per cent from unknown 'grey' sources, and 15 per cent from either Mayor or Northland (Seelenfreund and Bollong 1989). Of these 254 were subsequently examined visually by a graduate student (Jones), indicating slightly higher proportions from Mayor Island and Northland but fewer unknowns (Furey 2002: 108). My own analysis of the same collection, undertaken in 2011, produced fairly similar results. An entirely separate collection of 873 flakes, visually sorted by Furey, gave proportions of 66 per cent Mayor, 28 per cent Northland, and three per cent 'grey'. Considering that these assemblages were visually sourced by different people the results are remarkably consistent, and do not differ significantly from those obtained by EDXRF (which may in fact be less reliable).

Table A2. Comparison of Houhora obsidian analyses

Analysis	N	Mayor Island	Pungaere	Grey	Uncertain
EDXRF	300	64%	18%	3%	15%
Visual (Jones)	254	68%	21%	4%	6%
Visual (Moore)	254	73%	19%	4%	4%
Visual (Furey)	873 #	66%	28%	3%	3%

separate collection

Case 3: Opita

Until the introduction of pXRF, relatively few studies had involved the analysis of assemblages by both visual examination and chemical methods. In this case a collection of 167 artefacts from the Opita site near Paeroa was initially sourced on the basis of visual attributes (using the procedure of Moore 1988), followed by analysis of 76 of those by PIXE (Neve *et al.* 1994). The visual examination assigned 97 (58 per cent) to Mayor Island, 55 (33 per cent) to Waihi, eight (5 per cent) to Great Barrier (Te Ahumata), and seven were 'unknown'. From the PIXE analysis 33 of the 34 artefacts originally assigned to Mayor Island were confirmed as being from that source; one was regarded as 'probable'. Of the 27 artefacts visually sourced to Waihi, the PIXE analysis confirmed that 26 were from there. Although none of the flakes were actually from Great Barrier (PIXE indicated six were from Whangamata and two from Waihi), and therefore 15 of the 167 (9 per cent) were incorrectly or not able to be sourced, this study clearly demonstrated that visual examination could produce reasonably reliable results.

Case 4: Site R11/859, Auckland

This unpublished study is one of the largest undertaken so far, and involved a total of 6523 pieces of obsidian of which about two thirds were >10 mm in diameter (Cruickshank 2011). The assemblage was initially divided into six different types based on visual attributes, then up to 30 samples from each type (150 in total) were selected for pXRF analysis. The bulk of the obsidian was assigned to two groups – Type A, considered to be from Te Ahumata, and Type B, from Mayor Island. Of the 30 pieces from Type A analysed by pXRF, 29 were sourced to Te Ahumata and one to Hahei. All 30 pieces analysed from Type B were allocated to Mayor Island.

Of the other groups, Type C (N = 38) consisted of obsidian which was brown in transmitted light, and attributed from pXRF analysis to Te Ahumata (21), Cooks Beach/Hahei (4), Fanal (2), Huruiki (1) and Whangamata (1). Although 'brown' obsidian does occur at most of these sources, it has not been recorded on Fanal Island, and it seems extraordinary that such material was apparently procured from five different localities. Type D (n = 21) comprised 'grey' obsidian containing phenocrysts and spherulites. All 21 pieces were analysed by pXRF and were attributed to Cooks Beach/Hahei (6), Whangamata (6), Te Ahumata (2), Fanal (2), Waihi (1) and Huruiki (1). However, spherulites have not been identified in Fanal obsidian, and are rare in Waihi material. Type E (n = 12) was all red-brown obsidian, which pXRF analysis attributed to Te Ahumata. The remaining group, Type X (n =26) consisted of pieces that had very poor translucency. These were assigned, from pXRF analysis, to Mayor (12), Great Barrier (9), Whangamata (4) and Kaeo (1).

In this study, therefore, about 98% of the obsidian appears to have been correctly assigned to sources through a combination of visual attributes and limited chemical analysis. Only one piece from Type A was definitely incorrectly assigned, and it is likely that use of a stronger light source could have resulted in most of the flakes in Type X being re-allocated to other groups. In particular, visual attributes (other than translucency) could almost certainly have confirmed whether the one piece from 'Kaeo' was likely to be from that source or not.

References

Best, S.B. 1975. *Adzes, Rocks and Men*. Unpublished M.A. research essay, University of Auckland, Auckland.

Bettinger, R.L., Delacorte, M.G., Jackson, R.J. 1984. Visual sourcing of central eastern Californian obsidians. In *Obsidian Studies in the Great Basin*, R.E. Hughes, (Ed). Contributions of the University of California Archaeological Research Facility No. 45, USA pp.63–78.

Booth, J., Booth, W., McAlister, A., Rewha, A. 2018. Korero around sources of obsidian artefacts found in the Bay of Islands and other parts of Northland. *Archaeology in New Zealand* 61 (4): 10–22.

Brassey, R.J.N. 1985. An analysis of some lithic artefact assemblages from Pouerua, Northland. Unpublished MPhil thesis, University of Auckland, Auckland.

Brassey, R., Seelenfreund, A. 1984. Sources of obsidian artefacts from Pouerua, Bay of Islands district. *New Zealand Archaeological Association Newsletter* 27: 39–42.

Braswell, G.E., Andrews, E.W., Glascock, M.D. 1994. The obsidian artifacts of Quelepa, El Salvador. *Ancient Mesoamerica* 5: 173–192.

Braswell, G.E., Clark, J.E., Aoyama, K., McKillop, H.I., Glascock, M.D. 2000. Determining the geological provenance of obsidian artifacts from the Maya region: a test of the efficacy of visual sourcing. *Latin American Antiquity* 11 (3): 269–282. DOI: 10.2307/972178

Brown, A., Pitman, D. 2019. Resource procurement and inter-regional connection in pre-contact Taranaki, New Zealand: new evidence from geochemical analysis of obsidian. *Archaeology in Oceania* 54 (3): 149–162. DOI: 10.1002/arco.5189

Cruickshank, A. 2011. Flaked stone material. In The NRD site 1. The archaeology. Campbell, M. (Ed). CFG Heritage Ltd., Auckland, pp.89–103.

Furey, L. 1983. Maruka investigations Stage III. Excavation of site N77/606. Unpublished report, Anthropology Department, University of Auckland.

Furey, L. 1986. The excavation of Westfield (R11/898), South Auckland. *Records of the Auckland Institute & Museum* 23: 1–24.

Furey, L. 2002. *Houhora. A Fourteenth Century Maori Village in Northland*. Bulletin of the Auckland Museum 19.

Green, R.C. 1962. Obsidian: its application to archaeology. *New Zealand Archaeological Association Newsletter* 5: 8–16.

Green, R.C. 1964. Sources, ages and exploitation of New Zealand obsidian: an interim report. *New Zealand Archaeological Association Newsletter* 7: 134–143.

Ladefoged, T.N., Wallace, R. 2010. Excavation of an undefended site R10/494 on Motutapu Island, New Zealand. *Archaeology in New Zealand* 53 (3): 170–184.

Law, R.G. 1972. Archaeology at Harataonga Bay, Great Barrier Island. *Records of the Auckland Institute & Museum* 9: 81–123.

Law, R.G. 1973. Tokoroa moa-hunter site, N75/1. *New Zealand Archaeological Association Newsletter* 16: 150–164.

Lawrence, M., McCoy, M.D., Barber, I., Walter R. 2014. Geochemical sourcing of obsidians from the Pūrākaunui site, South Island, New Zealand. *Archaeology in Oceania* 49 (3): 158–163. DOI: 10.1002/arco.5032

Leach, B.F., Anderson, A.J. 1978. The prehistoric sources of Palliser Bay obsidian. *Journal of Archaeological Science* 5: 301–307. DOI: 10.1016/0305-4403(78)90047-X

Leach, B.F., de Souza P. 1979. The changing proportions of Mayor Island obsidian in New Zealand prehistory. *New Zealand Journal of Archaeology* 1: 29–51.

McAlister, A. 2019. On provenance studies of New Zealand obsidians: a pXRF-based geochemical reference dataset and a review of analytical methods. *Archaeology in Oceania* 54: 131–148. DOI: 10.1002/arco.5192

McCoy, M.D., Jorgensen, A., Glover, H., Stevenson, C. *et al.* 2018. Geochemical sourcing of New Zealand obsidians by portable X-ray fluorescence from 2011 to 2018. *Journal of Open Archaeology Data* 7:1. DOI: 10.5334/joad.52

Moore, P.R. 1983. Geology and geochemistry of obsidian deposits in the Cooks Beach-Hahei area, Coromandel Peninsula: a contribution to archaeological sourcing studies. *New Zealand Journal of Science* 16: 523–533.

Moore, P.R. 1988. Physical characteristics of New Zealand obsidians and their use in archaeological sourcing studies. Unpublished report.

Moore, P.R. 1999. Whangamata obsidian, Coromandel Peninsula. *Archaeology in New Zealand* 42: 289–294.

Moore, P.R. 2004. Sources of the Kohika obsidian artefacts. In *Kohika. The Archaeology of a Late Maori Lake Village in the Ngati Awa Rohe, Bay of Plenty, New Zealand*. Irwin, G. (Ed.) Auckland University Press, Auckland, pp.168–176.

Moore, P.R. 2005. Cultural distribution of the Waihi obsidian. *Archaeology in New Zealand* 48: 70–76.

Moore P.R. 2011a. The Taupo obsidian source, central North Island, New Zealand. *Journal of the Royal Society of New Zealand* 41 (2): 205–215. DOI: 10.1080/03036758.2010.529919

Moore, P.R. 2011b. Cultural distribution of obsidian along the Waikato-King Country coastline, North Island, New Zealand. *Journal of Pacific Archaeology* 2: 29–39. DOI: 10.70460/jpa.v2i1.45

Moore, P.R. 2012a. The obsidian sources of Northland, New Zealand. *Journal of the Royal Society of New Zealand* 42 (4): 257–274. DOI: 10.1080/03036758.2011.607834

Moore, P.R. 2012b. Procurement and cultural distribution of obsidian in northern New Zealand. *Journal of Pacific Archaeology* 3 (2): 17–32. DOI: 10.70460/jpa.v3i2.87

Moore, P.R. 2012c. Obsidian sources of the Taupo Volcanic Zone, central North Island, New Zealand. *Rapa Nui Journal* 26 (2): 17–28.

Moore, P.R. 2012d. Sourcing Mayor Island obsidian. *Archaeology in New Zealand* 55 (4): 238–243.

Moore, P.R. 2013. Obsidian sources of the Coromandel Volcanic Zone, northern New Zealand. *Journal of the Royal Society of New Zealand* 43 (1): 38–57. DOI: 10.1080/03036758.2011.576684

Moore P. 2015. The significance of cortex on Mayor Island obsidian. *Archaeology in New Zealand* 58 (2): 69–75.

Moore P. 2020. The Rotorua obsidian source revisited. *Archaeology in New Zealand* 63 (1): 31–38.

Moore, P. 2024. How many obsidian sources are there in New Zealand? *Archaeology in New Zealand* 67: 17–25.

Moore, P., Coster, J. 1989. Waihi obsidian. *Archaeology in New Zealand* 32: 26–30.

Moore, P.R., Coster, J. 2015. Evidence of a well-developed obsidian distribution network in the Far North of New Zealand: new data from the Aupouri Peninsula. *Journal of Pacific Archaeology* 6 (1): 1–17. DOI: 10.70460/jpa.v6i1.135

Moore, P.R., McAlister, A., Seumanutafa, H. (forthcoming). Making connections: analysis of obsidian artifact assemblages from coastal sites in the Canterbury region, South Island, New Zealand. *Journal of Island and Coastal Archaeology*.

Mosley, B., McCoy, M.D. 2010. Sourcing obsidian and pitchstone from the Wakanui site, Canterbury, New Zealand. *Rapa Nui Journal* 24 (2): 6–15.

Neve, S.R., Barker, P.H., Sheppard, P.J. 1994. Obsidian sourcing by PIXE analysis at AURA 2. *New Zealand Journal of Archaeology* 16: 93–121.

Psota, S. 1990. Re-examining the potential to visually source western Great Basin obsidians. Paper presented at annual meeting of the Society for California Archaeology, Foster City, USA, August 1990.

Ritchie, N.A., Moore, P.R., Ogden, J. 2009. An early artefact assemblage from the northern Waikato coast, New Zealand. *New Zealand Journal of Archaeology* 30 (2008): 89–111.

Robinson, J.J. 2016. *Tawhiti Rahi: Nga Poito o te Kupenga o Toi te Huatahi – a float of the Fishing Net of Toi te Huatahi. A Multi-disciplinary Study of Māori Settlement of Tawhiti Rahi, an Offshore Island in Northern New Zealand*. Unpublished PhD dissertation, University of Otago, Dunedin.

Seelenfreund, A., Bollong, C. 1989. The sourcing of New Zealand archaeological obsidian artefacts using energy-dispersive XRF spectroscopy. In *Saying So Doesnt Make It So: Papers in Honour of B. Foss Leach*. Sutton, D. (Ed.). New Zealand Archaeological Association monograph 26, pp. 147–168.

Shelley, D. 1993. *Igneous and Metamorphic Rocks Under The Microscope*. Chapman & Hall.

Sheppard, P.J. 2004. Moving stones: comments on the archaeology of spatial interaction in New Zealand. In *Change Through Time: Fifty Years of New Zealand Archaeology*. Furey, L., Holdaway, S. (Eds). New Zealand Archaeological Association monograph 26, pp. 147–168.

Sheppard, P.J., Irwin, G., Lin, J., McCaffrey, C.P. 2011. Characterisation of New Zealand obsidian using PXRF. *Journal of Archaeological Science* 38 (1): 45–56. DOI: 10.1016/j.jas.2010.08.007

Tykot, R.H. 1996. Obsidian procurement and distribution in the central and western Mediterranean. *Journal of Mediterranean Archaeology* 9: 39–82.

Vernon, R.H. 2004. *A Practical Guide to Rock Microstructure*. Cambridge University Press.

Walter R., Jacomb, C., Bowron-Muth, S. 2010. Colonisation, mobility and exchange in New Zealand prehistory. *Antiquity* 84: 497–513. DOI: 10.1017/S0003598X00066734

Ward, G.K. 1973. Obsidian source localities in the North Island of New Zealand. *New Zealand Archaeological Association Newsletter* 16: 85–103.

Ward, G.K. 1974. A paradigm for sourcing New Zealand archaeological obsidians. *Journal of the Royal Society of New Zealand* 4: 47–62. DOI: 10.1080/03036758.1974.10419406