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ENGAGEMENT PAPER

Working with the Public: How an Unusual Museum Enquiry Turned into Travels Through Time and Space

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Museum enquiries offer a unique opportunity to engage on a one-to-one level with members of the public. This paper covers an unusual enquiry from 2013 of an unknown tooth that was brought into Plymouth City Museum and Art Gallery for identification. We highlight how museum enquiries can engage with members of the public by involving them directly with original scientific research. The tooth was found in a garden in Plymouth with no associated data of about where it originated. We identified the tooth, and the enquirer researched the history of the house. The tooth gave the appearance of a sub-fossil so with the large number of Quaternary sites in Plymouth, together with the identification of the previous owner on the site, there were valid reasons to undertake testing of the tooth to determine its origin. Strontium (Sr) isotope analysis of the tooth was carried out to determine if the tooth was British and radiocarbon dating was undertaken to work out the age of the tooth. The $^{87}Sr/^{86}Sr$ of the leopard tooth gave a value of 0.716131, with Sr concentrations at 568ppm. This is a high concentration of Sr ppm relative to other British data, suggesting a non-British origin. The radiocarbon measurement was 187 ± 24 years BP (University of Oxford Radiocarbon Accelerator Unit reference OxA-30390). This places the tooth not in the Pleistocene, but between 1739 and 1787 AD. The site where the tooth was discovered was owned by the brother of Linnaeus Tripe who travelled across India and Burma. We argue that the results of this study demonstrate that this leopard tooth was originally from India or Burma, and brought into Britain by Tripe.

Keywords: Museum enquiry; Linnaeus Tripe; Plymouth; PCMAG; Strontium Isotope Analysis; Public engagement

Introduction

Plymouth City Museum and Art Gallery (PCMAG) opened in 1910 for the enjoyment, inspiration and education of the people of Plymouth (Freedman, 2012). A large number of the collections were obtained before 1910, and many of the main collections were acquired between the museum opening and the mid-1900s. PCMAG's collections have a local focus, and where the object itself may not be local, the collector, or story behind that object, is. The Human History collections include a large collection of local history objects (photographs, social history objects), archaeology (locally excavated bronze age, iron age and medieval finds), and world cultures (objects from Africa, America, Asia and Oceania). With a Plymouth or South West focus the art collections include fine art (paintings, drawings prints and sculptures) and decorative art (metalwork, glass, furniture, costumes, textiles and ceramics). The diverse natural history collections include entomology, spirit preserved specimens, taxidermy, herbaria, minerals and a large number of local Quaternary fossils. With around 100,000 visitors to the museum sites annually, the museum galleries display objects from all areas of the collections.

PCMAG's visibility within the local community is high through running a variety of activities and events in and around the city. This helps to promote the collections and their unique stories, as well as making the museum feel a part of people's lives. One area where public engagement is carried out by all staff on a one-to-one level is through public enquiries. Across the departments, PCMAG receives approximately 1000 enquires per year in person or through telephone calls and emails. The number of enquiries varies with each department and can range from collection queries to object identification. The natural history department receives around 200 enquiries annually, with approximately 30% relating to the collections, 10% general (talks, advice) and 60% specimen identifications. Most of the identifications are brought into the museum in person without appointment, and can take anywhere from 5 minutes to 30 minutes to deal with depending on what the specimen is and how engaged the enquirer is. For identifications which cannot be dealt with immediately,

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the enquirer can leave the specimen with the curator to investigate further.

No data analysis has been published on the benefits of a museum enquiry service so the true value of public enquiries remains anecdotal (for some more recent blog posts see Freedman, 2014a; Freedman, 2014b; Miller 2015). Some authors have indicated how enquiries are important for both the museum and the enquirer, but without real, detailed analysis evaluating the experience of the individual bringing that item in (Knell & Taylor, 1989; Young, 1972). Taking the time to answer an enquiry can be beneficial to the museum by building relationships with the public, and learning more about their local environment (Knell & Taylor, 1989). Young (1972) and Clarke (1984) note how enquiries can stimulate curiosity for the enquirer whilst potentially increasing knowledge of the museum collections, and possible donations. Curators should be able to acknowledge the limits of their own knowledge and expertise so as not to give false information or mislead the enquirer (Clarke, 1984; Knell & Taylor, 1989; Museums Association, 2008).

Someone contacting the museum to find out about an object *wants* to know more about that object. What that individual has found is special to them. By spending time with a person, or a family, the museum is engaging with them and helping to feed their curiosity to discover more (Freedman, 2014b), and by providing this simple public service museums build up relationships with the public which can result in valuable additions to the museum collections. Many museums receive donations which are in line with their collecting policy as a result of an enquiry – from crocodile teeth (Steel, 2015, *pers comm.*) to cockroaches (Hancock, 2015, *pers comm.*). Some donations through enquiries have even resulted in new scientific publications, including gastroliths containing remains of invasive crayfish (Mortimer et al 2012), dinosaur footprints (Price, 2014), the Happisburgh handaxe (Parfitt et al. 2010) and ichthyosaur remains (Brusatte et al. 2015). Clearly, there are benefits for the public and for the museum.

On 25th April 2013, Mr Martin Rickard visited PCMAG with a tooth discovered in 1960 by his father in the garden of their house in Stoke, Plymouth. It was a canine of a carnivore, but I (JF) was unsure about which species (**Figure 1**). The tooth was bigger than a fox or wolf canine, but it was thinner and appeared sharper than a hyena canine. I suspected that it belonged to a big cat. The yellow/orange colouring gave it a similar look to subfossil remains I have seen which added to the mystery (see **Figure 1**).

With such an intriguing specimen I said I would look into trying to identify the tooth, and Mr Rickard offered to have a dig into the background of the house to find out

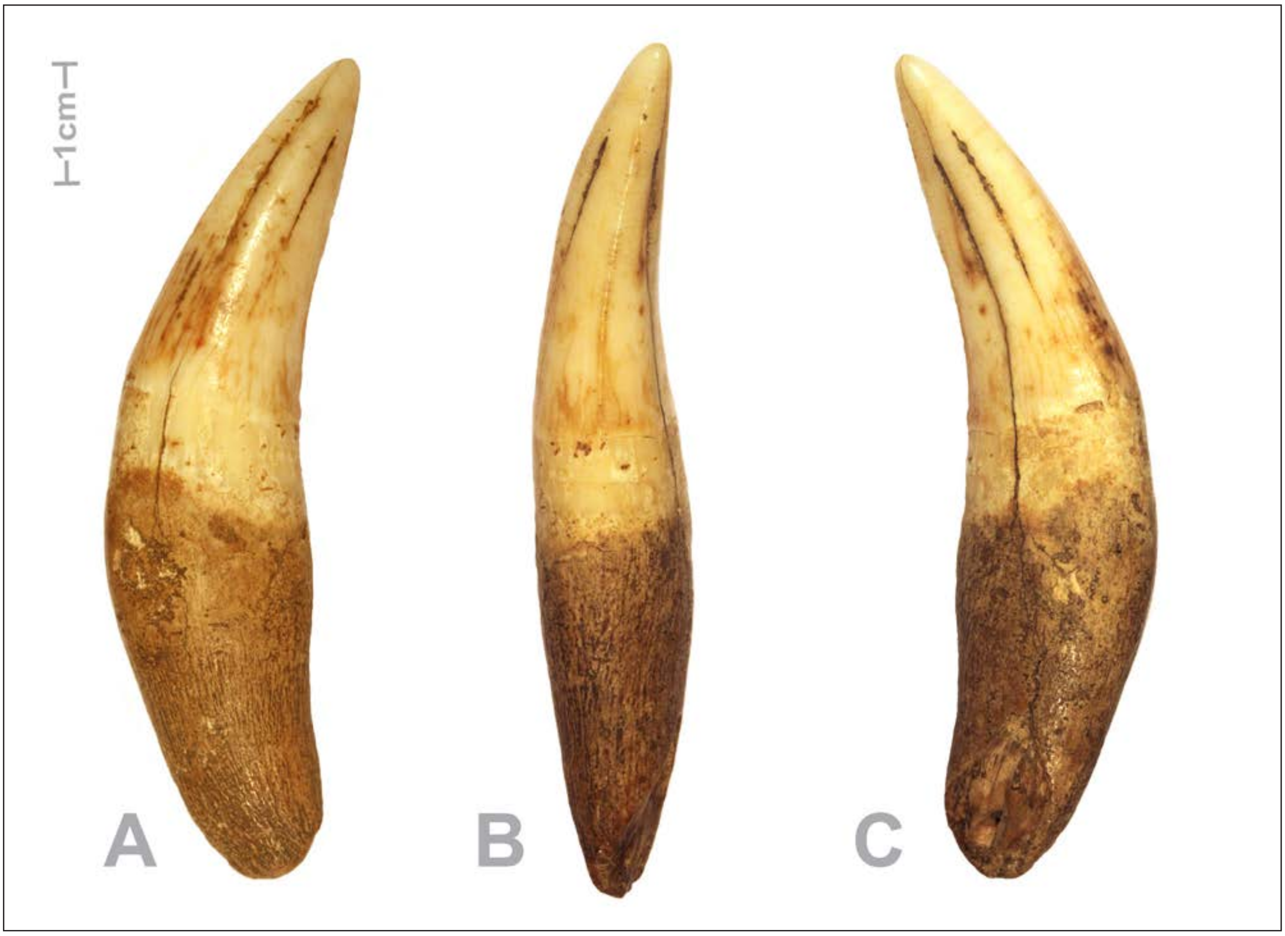

Figure 1: The tooth of *Panthera pardus* found in the garden of the house in Stoke, Plymouth. The tooth is larger than a wolf canine, but thinner and more slender than a hyena or lion canine. A = buccal view; B = distal view; C = lingual view. (Museum number: PLYMG.2013.187). (Image taken with Cannon EOS7D camera with EFS 60mm lens by Jan Freedman and Jodie Fisher).

if there was some information in its history. Mr Rickard lent the tooth to PCMAG while we both undertook our research. This paper outlines how museum enquiries can engage with members of the public by involving them directly with a piece of original research.

2. Identification of the tooth

The tooth didn't match any of the carnivore specimens in the collections at PCMAG. To seek assistance in identifying this specimen I (JF) contacted a colleague who cares for a large collection of cranial and post cranial skeletons at the Horniman Museum and Gardens. It was identified as an upper right canine of a leopard (*Panthera pardus*), verified on photos via Twitter (Viscardi, 2013a; 2013b). Along with being more slender than the other big cats, leopard canines show wear from the canine below, which is clearly visible in this specimen (**Figure 1**).

Why this leopard tooth was in Mr Rickard's backyard was unknown. Modern leopards have a large distribution, spreading from Sub-Saharan Africa, the Middle East, Southeast Asia, and Northeast Siberia (Nowell & Jackson, 1996). With a fairly varied environment across the African and Asian continents, there are ten sub-species of leopard, from the Sri Lankan leopard (*P. pardus kotiya*) to the open savannah African leopard (*P. p. pardus*) (Diedrich, 2013). However, this tooth appeared to display the distinctive yellow/light-brown colouring suggesting a potential subfossil origin closer to home.

I contacted Mr Rickard to let him know what animal the tooth was from. He said he had always assumed it belonged to a cat, and although his family had called it the 'Tiger tooth', he wasn't sure which species it really belonged to. Mr Rickard was excited to find out that it was the tooth of a leopard, but as we talked, it opened up more questions: Where did it come from? How did it get there? I discussed the plentiful Quaternary sites in Plymouth which I know of from the collections at PCMAG and our history files. There were several Pleistocene sites in Plymouth; Hoe Beach discovered in 1808 (Worth, 1886), Oreston first excavated in 1817 (Buckland, 1823; Cottle, 1829), Stonehouse discovered later, around 1835 (Worth, 1886), and Cattedown brought to the attention of science in 1886 (Worth, 1887). The majority of these sites are some of the earliest recordings of Quaternary remains discovered in Britain, however sadly most of the sites, and the specimens themselves, no longer exist. I knew of one Felid to have been recovered from two sites in Plymouth: cave lion (*Panthera spelaea*) has been recorded from Cattedown Caves (Worth, 1887) and Oreston Caves (Chamberlain & Ray, 1994). With a rich list of fauna, and evidence of big cats in Plymouth sites, it is not improbable that at one time leopards were present.

Sub-fossil remains of leopards in British Pleistocene sites are extremely rare. Only two localities are known to hold fossil leopard material; Bleadon Cavern, Somerset and Pontnewydd Cave, North Wales (Currant, 1984; Currant & Jacobi, 2001; Currant 2004). Schmid (1940) notes five other localities, but these remain tentative: Newbon, Essex; Spritsail Tor, Gower; Banwell, Somerset; Hutton/Sandford Hill, Somerset; and Cresswell Crags, Derbyshire (**Figure 2**). Currant and Jacobi (2001) identify Schmid's specimen from Banwell, Somerset as being mislabelled, and place the locality as Bleadon Cavern. The rarity of leopard remains in Pleistocene deposits may be due to the general open air habitat of these felids, subsequently leaving a poor fossil record. Combined with this, predator numbers are much lower than prey, resulting in even fewer fossils preserved. Bleadon Cavern and Pontnewydd Cave, confirmed to hold leopard teeth, are both sites in the South West of Britain.

3. History of the house

While the tooth was being identified, Mr Rickard had spent time looking into the history of the house. The tooth was discovered in July 1960 in a back garden in Stoke, Plymouth (**Figure 3**). It was found by Mr Rickard's father who was using a grass spoil heap next to an old World War 2 air raid shelter to fill in an old path. Since his initial enquiry in April 2013, Mr Rickard had carried out research at the Plymouth Local Studies Library and gathered a lot of information about the history of the site, including maps and old newspaper articles.

The site of the current house was once part of the large grounds of a grand Regency house, known as The Elms (Western Daily Mercury, 1899), which records show was demolished in the 1930s (**Figure 4**). The owner of The Elms, Dr Lorenzo Metham, was the son of Dr Cornelius Tripe (Lorenzo took his wife's surname when he married) (Western Morning News, 1899). The link to the tooth may be with Lorenzo's brother: Linnaeus Tripe. Stationed in South India when he worked for the army of the East India Company, Linnaeus Tripe (1822–1902) travelled extensively across India, and his collection of early photographs are held at the Victoria and Albert Museum, London (V&A, 2014). Although Tripe did collect shells and corals (V&A, 2014) with a small number of shells held at the Natural History Museum, London, the authors have found no sub-fossil specimens collected by Tripe. As a well-known Plymouthian, and having an interest in natural history, it is possible (although not confirmed) he would have been acquainted with other local naturalists, including Richard Nicolls Worth, who excavated and studied the Cattedown Bone Caves.

What Mr Rickard discovered presented two scenarios: the tooth was from a Pleistocene leopard in Britain or it was more recently brought to Plymouth. Mr Rickard and I wanted to see if we could find out if the specimen was from the Plymouth area, or elsewhere in Britain. I used Twitter to ask followers whether there was a way of measuring a chemical signature in a tooth or bone that could record its place of origin (Freedman, 2013). Rare earth elements, Strontium and Oxygen isotopes were suggested as possible elements that could be used (Burger, 2013; Fisher, 2013). I was put in touch with Jane Evans at the NERC Isotope Geosciences Laboratory at the British Geological Society, who was keen to assist in the analysis. Social media provided a possible method in identifying the origin of this leopard tooth.

4. Investigations into the origins of the tooth

4.1. Isotopes in the tooth

Isotope analysis has been used in several studies to determine the original locality of specimens (for examples see Garcia-Guixè et al., 2009; Degryse et al., 2012; Evans et al.,

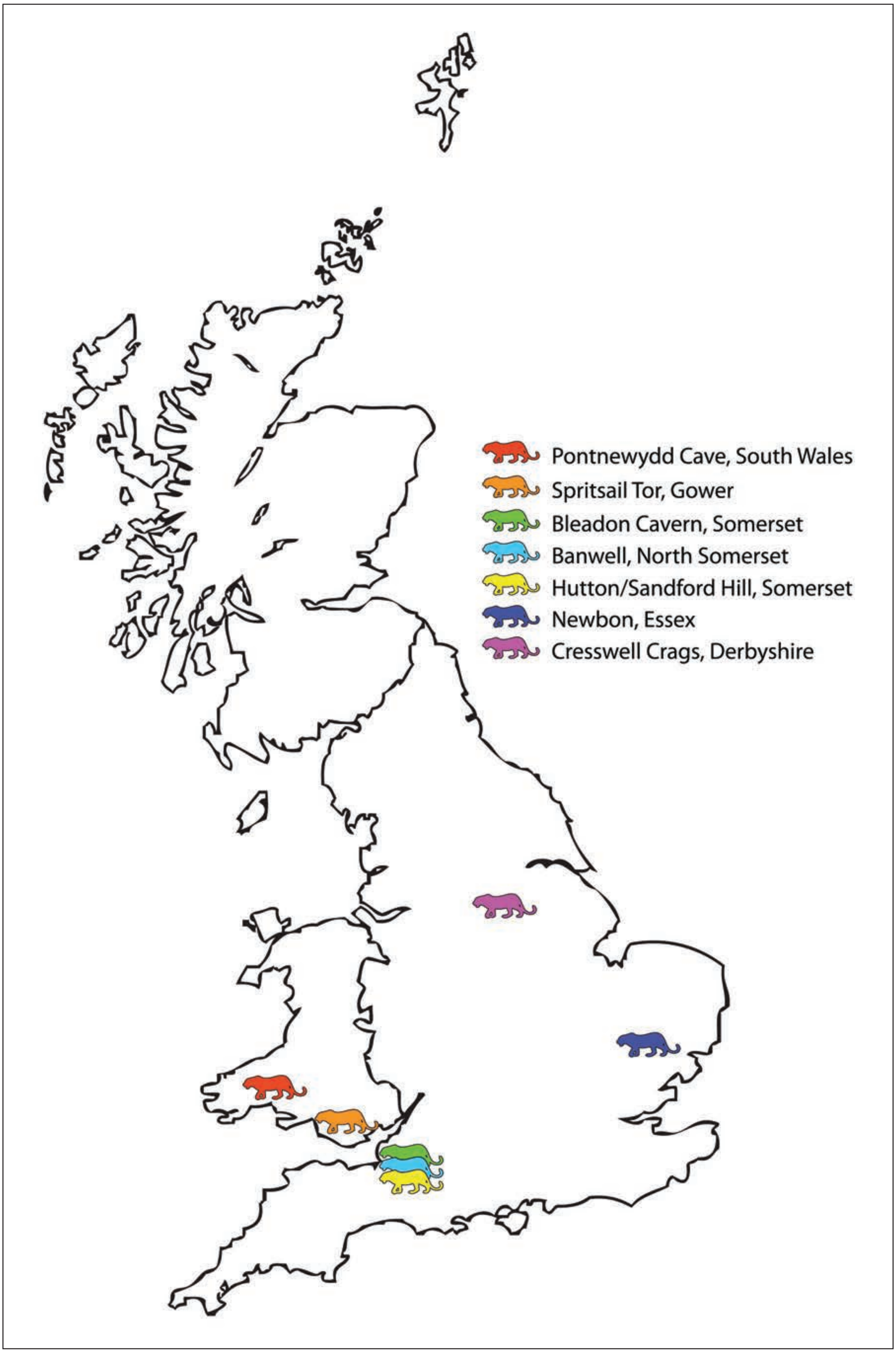

Figure 2: Distribution of British Pleistocene leopards (*Panthera pardus)* (after Schmid, 1940; Currant, 1984; Currant and Jacobi, 2001; Currant, 2004). The specimens from Newbon, Essex; Spritsail Tor, Gower; Banwell, Somerset; Hutton/Sandford Hill, Somerset; and Cresswell Crags, Derbyshire, as mentioned by Schmid (1940) remain tentative. The specimen from Banwell (Schmid, 1940) is very likely to be from Bleadon Cavern in Somerset (Currant & Jacobi, 2001). Note the two confirmed sites (Bleadon and Pontnewydd) are in the South West, just north of Plymouth.

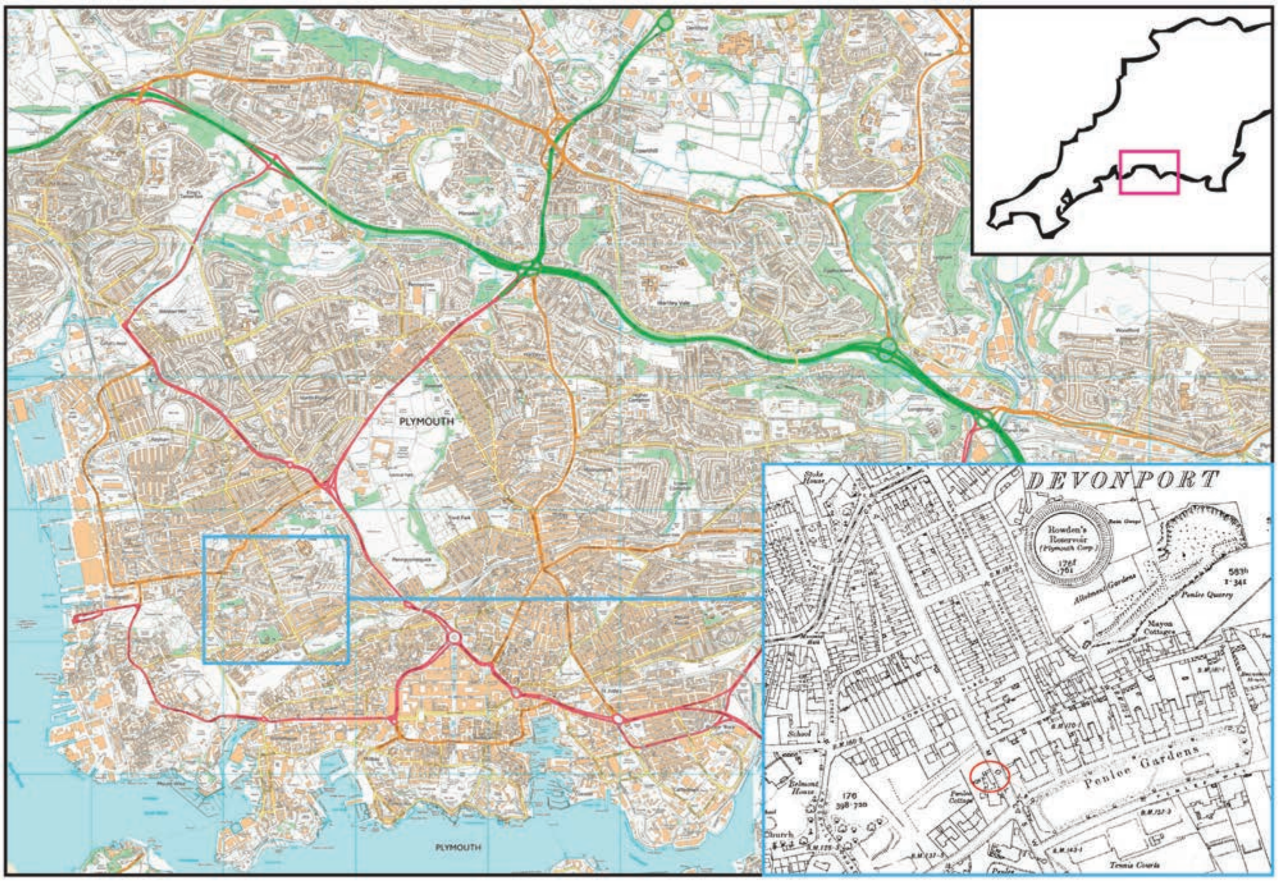

Figure 3: The locality of the leopard canine found by Mr Rickard's father in 1960, in Stoke, Plymouth. (Map of Plymouth: © Crown Copyright, Plymouth City Council, Licence No. 100018633. Inset;Map of Devonport: 1933, Ordnance Survey map. Devonport. No other information. From Plymouth Libraries.)

2010; Evans, Chenery & Montgomery, 2012; Blake et al., 2013). Oxygen isotope analysis can be used to identify the region of origin of animals (e.g. Garcia-Guixè et al., 2009) and has been used for human migration studies (e.g. Dupras, 2001; Budd et al., 2004). The composition of the oxygen isotopes in the tooth enamel can be compared with rainwater data through a conversion equation to account for the isotope fractionation in the body. As no conversion equation exists for the higher carnivores, and there is no published data for direct composition between big cats, this was considered an inappropriate technique for this sample. This study was therefore restricted to using Strontium (Sr) isotope analysis.

As with Oxygen isotope analysis outlined above, Sr isotope analysis of tooth enamel can be used to assess the relationship between a sample and its place of burial, and in the case of a mismatch, can be used to identify the likely place origin (for examples see Evans et al., 2010; Evans, Chenery & Montgomery, 2012; Blake et al., 2013). Strontium is an element that follows calcium into teeth and bones; it is used in provenance studies because its isotopic composition varies and this variation can be related to the geographic location through the nature of the underlying rocks that supply the Sr into the biosphere. Radiogenic ^{87}Sr in rocks is produced though the decay of Rubidium (specifically ^{87}Rb) as it accumulates though time. The older or more Rb rich a rock is the more its ^{87}Sr/^{86}Sr will increase. As the rock is weathered to produce soils the Sr passes up into the soil and it taken up by plants so entering the food chain. It is then consumed and moves up the food chain. These variations have been mapped across Britain (Evans et al. 2010) providing a method of relating individuals to the land on which they were raised (**Figure 5**). Within the archaeological context this analysis is restricted to the use of tooth enamel as this robust material preserves well and retains its life signal. The majority of samples in England produces 87Sr/86Sr values between 0.708 and 0.713. Some higher values have been recorded in plant composition and water in Scotland but even in this area of very old rocks values over 0.713 are scarce.

Methods for the Strontium isotopes measurements

The canine was sent to the NERC Isotopes Geosciences Laboratory at the British Geological Survey for Strontium (Sr) isotope analysis. The surface enamel of the tooth was cleaned by abrading to a depth of >100 microns using a tungsten carbide dental burr with the removed material discarded. A thin wedge was cut from the convex surface of the tooth using a flexible diamond edged rotary dental saw and dentine was removed from the inner surface using a diamond coated burr. The enamel was transferred to a clean (class 100, laminar flow) working area for further preparation. The sample was cleaned ultrasonically

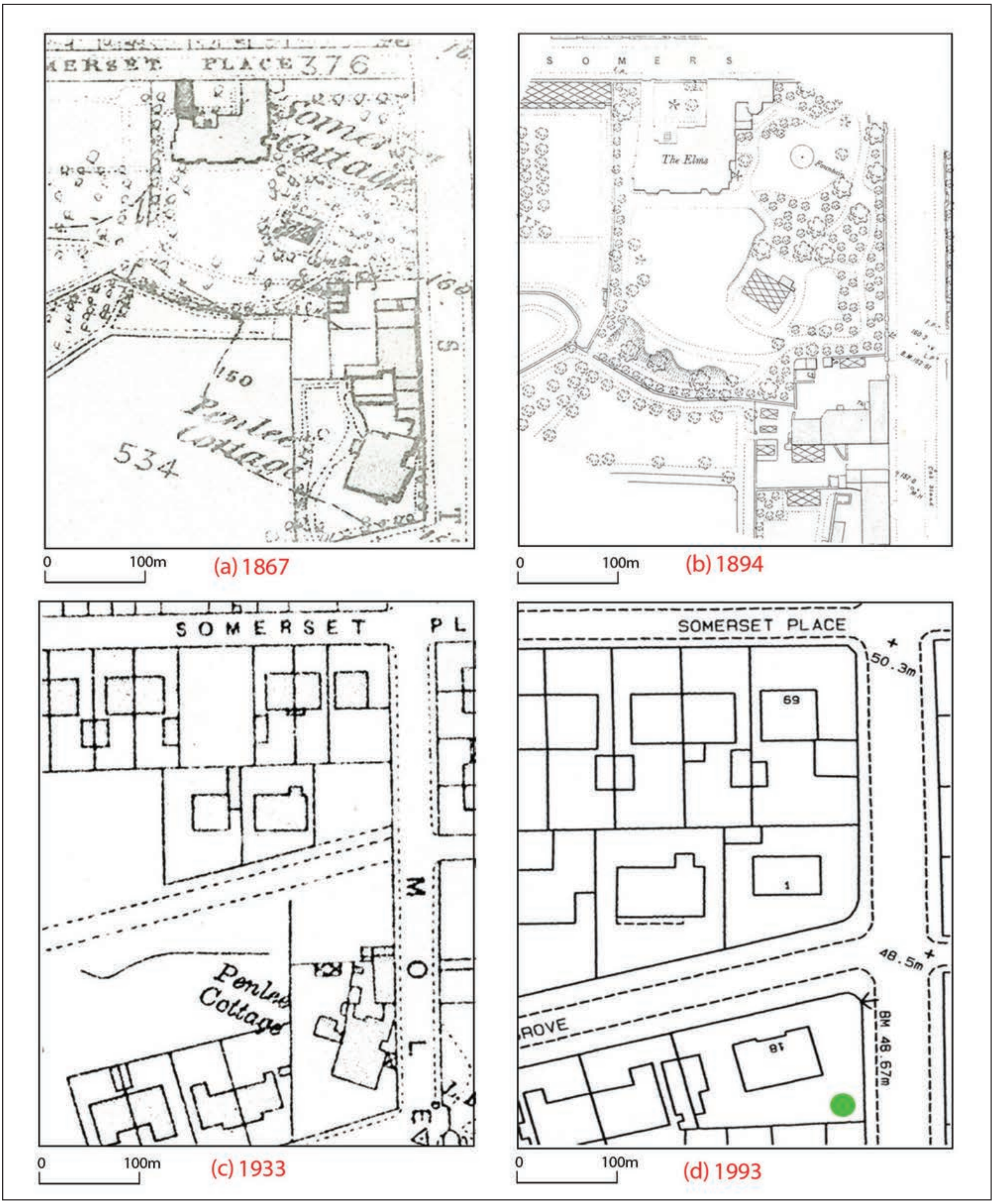

Figure 4: The changing surroundings of the site where the tooth was discovered (green dot) showing the development of the area over the years. The grounds of The Elms extended over a large area, until it was knocked down and built on in the 1930s. (a) 1867: cropped from Map of Stoke, 1867. No other information. (b) 1894: cropped from The Elms, Ordnance Survey Office Southampton, XX111.7.14. (c) 1933 Ordnance Survey map. Devonport. No other information. (d) Stoke, Ordnance Survey © Crown Copyright, Plymouth City Council, Licence No. 100018633. All maps from Plymouth Libraries.

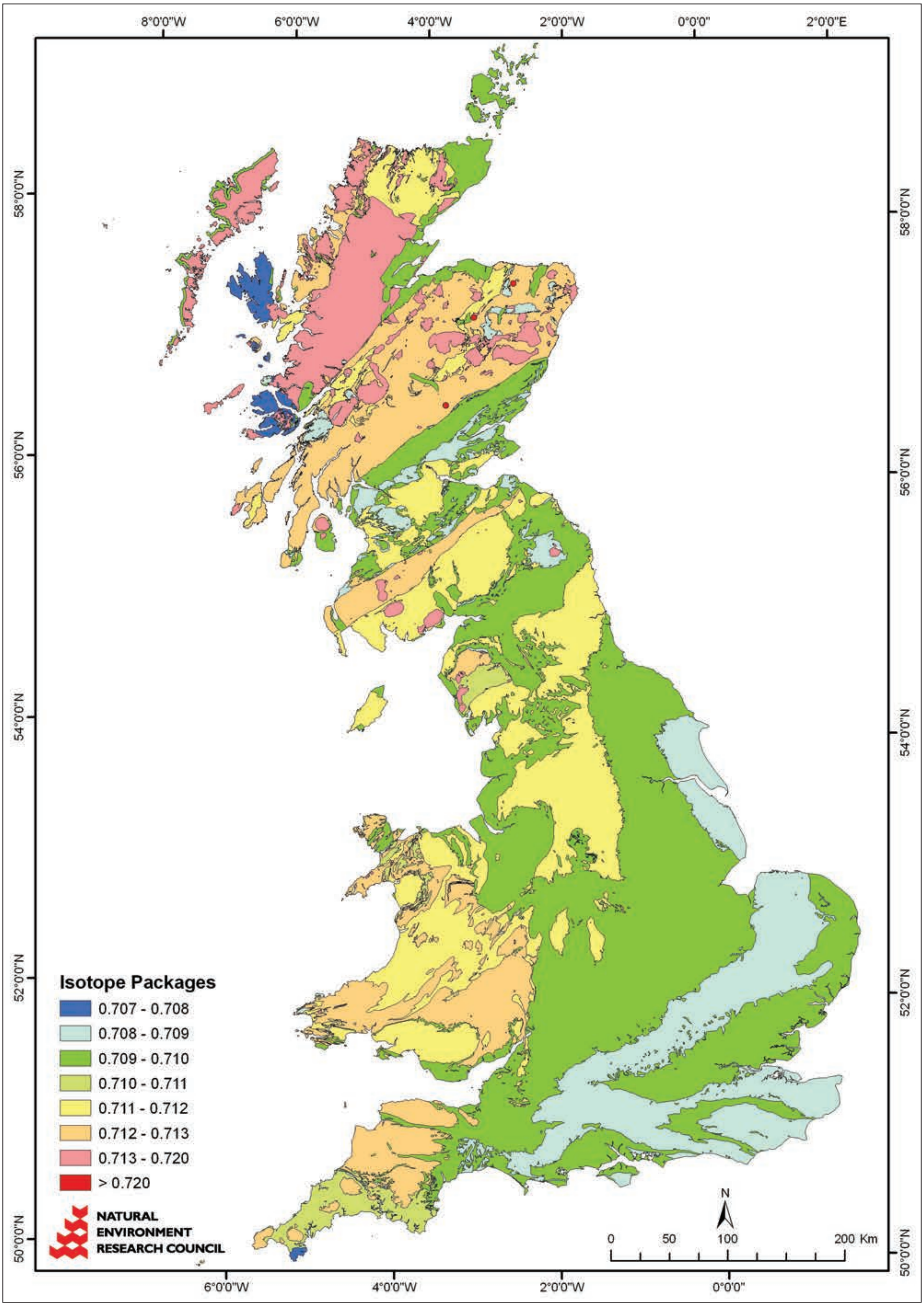

Figure 5: $^{87}Sr/^{86}Sr$ biosphere map for Britain illustrating the different Sr levels across England, Scotland and Wales (from Evans, Chenery & Montgomery, 2012).

in high purity water, rinsed twice then placed in deionised water on a hot plate at 50°C for one hour, rinsed twice, dried and then weighed into pre-cleaned Teflon beakers. The sample was mixed with ^{84}Sr tracer solution and dissolved in Teflon distilled 8M HNO_3. Strontium was collected using Dowex resin columns and loaded into a Re Filament following the method of Birck (1986). The isotope composition and concentrations were determined by Thermal Ionisation Mass Spectroscopy (TIMS) using a Thermo Triton multi-collector mass spectrometer. The international standard for ^{87}Sr /^{86}Sr, NBS987, gave a value of 0.710251 ± .000012 (n = 19, 2SD).

Strontium isotope analysis results

The ^{87}Sr /^{86}Sr isotope analysis of the leopard tooth gave a value of 0.71613, with Sr concentrations at 568ppm. This is a high Sr concentration in comparison with British human data (Evans, Chenery & Montgomery, 2012) and British animal data (Towers et al., 2010; Minniti et al., 2014) (**Figure 6**). The locality of the find (Plymouth, UK) is a coastal area, where the local biosphere values are predicted to be between 0.710 and 0.711 (Evans, Chenery & Montgomery, 2012). High Sr concentrations do occur during diagenetic alteration, but are also known to occur in herbivore enamel from hotter, drier climates (Pellegrini et al., 2008; Bogaard et al., 2013). The ^{87}Sr /^{86}Srisotope composition showed the tooth was definitely not of local SW England origin, and would be a rare value within the British data sets. This, in combination with the high Sr concentrations , suggests this tooth was not of British origin.

The results indicate that the tooth is not from Britain. However, this does not necessarily indicate a recent origin of the tooth. An interesting study by McFarlane and Lundberg (2013) suggests that teeth of the European Scimitar Cat (*Homotherium latidens*) were transported from Europe into British sites by Palaeolithic peoples. A European origin for the other large British felid species, the cave lion (*Panthera spelaea*), has not been proposed due to the large number of post-cranial remains discovered, e.g. at Kirkdale Caves, Yorkshire (Buckland, 1822), Cattedown Caves, Plymouth (Worth, 1887) and Pin Hole Caves, Derbyshire (Boyd Dawkins, 1877): it is unlikely that people were transporting large and heavy cave lion post-cranial bones across Europe. The only remains of leopards excavated so far at the two sites in Britain are fossil teeth. Remains of cranial and post-cranial *P. pardus* have been excavated from 77 sites (both open sites and caves) across Europe (see Diedrich, 2013, and references therein). With such a large number of European sites, and very few British sites, it could be possible that the leopard teeth were introduced: Pontnewydd Cave does have evidence of Palaeolithic occupancy (Currant, 1984), but Bleadon Cavern shows no signs of human presence (Currant, 2004).

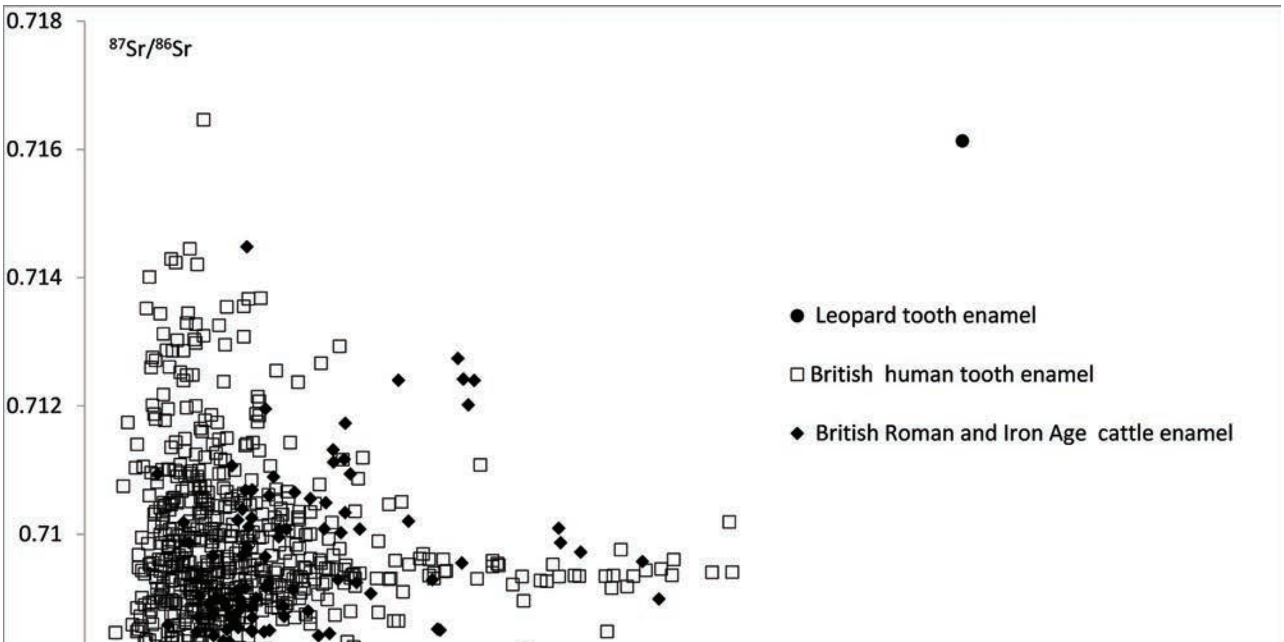

Figure 6: A comparison of the strontium isotope composition (y-axis) and strontium concentration (x-axis) from the enamel of the leopard tooth (PLYMG.2013.187) along with archaeological British data sets for human enamel (Evans, Chenery & Montgomery, 2012) and for cattle from southern England (Minniti et al., 2014).

4.2. The dating game

With the interesting strontium isotope results we wanted to determine the age of this specimen. We were limited with actually dating the organic remains as there were no associated sediment/minerals with the tooth. There are several methods of dating organic remains each with their own benefits and limitations, including radiocarbon dating, amino acid dating, and electron spin resonance. Amino acids are able to date bone up to around 700,000 years ago by measuring the rate at which the protein 'flips' after death from its original position in life. This method has been used successfully to date fauna (for examples see Bada & Helfman, 1975; Miller et al. 1999; Magee et al. 2009; Torres et al., 2001). Amino acid dating is not entirely reliable, because they are fragile proteins which can be affected by many variables; for example, water percolating through a specimen can break it down faster. Another method that can be used is Electron Spin Resonance (ESR) which calculates how long electrons have been trapped in an object which have become knocked out of their orbit. This technique can date back to 1 million years ago, and has been successful in several dating studies (for examples, see Chase et al., 2007; Kerber et al., 2010; Kinoshita et al., 2010; Lopes et al., 2010).

However, the fauna recorded from the sites in Plymouth (Buckland, 1823; Cottle, 1829; Chamberlain & Ray, 1994; Worth, 1886) indicated a late Devensian date (around 30,000 years BP) (Currant & Jacobi, 2001). It was decided to date the tooth using radiocarbon dating. This method examines the ratio of ^{14}C to ^{13}C, which is equal when an organism is alive but ^{14}C begins to decay to ^{13}C after death. The analysis and calculations of radiocarbon dating are robust and have been used successfully to date the majority of late Quaternary fauna. Radiocarbon dating does have its limitations: the half-life of carbon is around 5,730 years which makes the dating possible back to something which is 50,000 years old. There is always the potential that collagen would not be present, as is sometimes the case for older specimens, or even younger specimens where the burial conditions are poor. Although limited to 50,000 years BP, a result of >50,000 would still indicate an ancient origin for this tooth.

We were fortunate enough to have a grant from the Marc Fitch Fund which covered the costs of radiocarbon dating this tooth.

Methods for the radiocarbon analysis

The University of Oxford Radiocarbon Accelerator Unit undertook keyhole sampling on the tooth to minimise external damage. A small hole in the enamel was drilled allowing the dentine below to be drilled out. The ^{14}C age is quoted in years BP (before 1950AD). The chemical pretreatment, target preparation and AMS measurement followed the procedures in Bronk Ramsey, Higham, & Leach (2004a), Bronk Ramsey, Higham, & Leach (2004b), and Bronk Ramsey et al. (2010).

Radiocarbon results

The radiocarbon measurement was 187 ±24 years BP (University of Oxford Radiocarbon Accelerator Unit reference OxA-30390). This places the tooth not in the Pleistocene, but between 1739 and 1787 AD.

5. An 18th century leopard from outside the UK

The strontium isotope data from human teeth in England and Wales shows a maximum value of 0.714 (Evans, Chenery & Montgomery, 2012), which may be more relevant to the leopard tooth, as both species are at the top of the food chain. However, the leopard tooth had an even higher value of 0.716. This relatively high Sr isotope analysis result is unlikely to have been caused by diagenesis because the hard enamel is stable and does not suffer from it (Trickett, 2003). Although **Figure 5** illustrates slightly higher Sr isotope readings in Scotland, it is highly unlikely that this tooth originated from a leopard in Scotland; Edinburgh Zoo first opened in 1913 (Edinburgh Zoo, 2014), over 100 years after the date of this tooth, and there have been no Quaternary records of leopard in this area (Stuart, 1982).

The radiocarbon date shows that this *P. pardus* canine is not Pleistocene in age. This along with the high results from the strontium isotope analysis indicates that this tooth is not from a British Pleistocene leopard. It is a tooth from a more recent specimen.

Modern leopards have a large distribution, spreading from Sub-Saharan Africa, the Middle East, Southeast Asia, and Northeast Siberia (Nowell & Jackson, 1996) and a fairly varied environment (Diedrich, 2013). The site where the tooth was discovered may provide the information as to where it originated from.

The grounds where the canine was discovered belonged to Dr Lorenzo Metham, whose brother was Linnaeus Tripe. Linnaeus was born in Devonport in 1822 and joined the East India Company when he was just 17 years old (Dewan, 2003). Many officers of the British Empire who were stationed with the East India Company mapped, studied, painted and sketched India and Burma's architecture and archaeology, which was an ideal way for the British government to learn more about this foreign land they were in control of; for the public, however, this made this exotic place more real (Taylor & Branford, 2014). After 11 years in India, Linnaeus Tripe returned on leave back to England where he learnt about the new art of photography (Dewan, 2003). Setting back out to India, Tripe's new skill in photography enabled him to travel extensively around India and Burma between 1854 and 1860 (Dewan, 2003; Taylor & Branford, 2014).

The 1800s was a time when people were collecting natural history for themselves or for museums. New and exotic places were being explored for the first time, and in these new environments new animals and plants were being seen for the first time by European eyes. Some, like Edward Blyth, sent specimens back from India for money: for dealers like Blyth it was this was their main source of income (Brandon-Jones, 1997). Others, who had the financial means, collected specimens they fancied for their own personal pleasure (Asma, 2001). Linnaeus Tripe collected a small number of natural history specimens in his time in India for his own pleasure. He collected marine shells from the Philippines and Mascarene Islands, one specimen is held at the Natural History Museum, London (Way, Barclay & Lowe, *pers. comm.* 2015); the type specimen of *Pleurotoma infrafusca* (Sowerby, 1893).

There is very little data available on strontium isotope analysis in India or Burma to allow us to determine the exact locality. However, recent strontium isotope work on modern human hair records from India have provided a value of 0.7161 (Font et al. 2012). We understand that the Sr isotope values may vary dramatically across India as it is such a large landmass, as it does across Britain. This data from Font et al. (2012) does indicate potentially higher Sr values and provides firm links with the history of this leopard tooth and the Sr isotope results obtained. With the results obtained from the chemical analysis of the tooth, the authors favour the view that this leopard tooth was brought to Plymouth from India by Linnaeus Tripe during the mid-1800s.

6. Engaging through enquiries

Today science is more accessible to the general public than ever before. Latest discoveries and new scientific research are discussed in the media, and even more commonly on online blogs. Blog posts dissect the technical jargon of a scientific paper, leaving the vital organs of the story exposed to be read with ease. In the 1990s, the Public Understanding of Science was established to connect science with the general public (Lewenstein, 1992): sieving out the scientific jargon and allowing science to be understood by more than just a select few. This actually goes back further than a few decades; Thomas Henry Huxley developed talks to the 'working men' in the 1860s, with the aim of making science more accessible (Desmond, 1994). These examples are engaging with the general public with more formal sessions focused on a specific science topic (Haywood & Besley, 2014).

Engaging directly with people through interactive events is another way of breaking down barriers where the public meet real scientists in informal learning settings (for examples see Freedman et al. 2010; Freedman, Fothergill & Smithers, 2010; Miller et al. 2013). A third successful and growing method of engaging with the general public is through 'Public Participation in Scientific Research' whereby members of the public contribute to the research directly (Shirk et al. 2012). This can take the shape of an exhibition in a museum where visitors can contribute their recordings of wildlife in their area, or volunteer to take part in research projects where they are gathering data (Haywood & Besley, 2014). In these cases, the person involved is learning about the science, and being a part of it, although they are only contributing a little data. Museum enquiries offer a unique opportunity for public participation in scientific research whereby the enquirer and the museum curator work together on a collaborative project learning from each other.

Museums received hundreds of enquires each year ranging from queries relating directly to the collections to object identifications. The majority of enquiries at PCMAG are object identifications where members of the public bring in an item they possess or have found and a curator helps to identify it. This provides museum curators with an opportunity to share our passion of our work through face-to-face enquiries and talk about our collections (Freedman, 2014a). Enquiries are an interesting way to engage with the public, because they are an audience who already has that curiosity; otherwise they wouldn't have brought it into the museum. The beauty of this curiosity is that the enquirer wants to find out even more, which benefits the museum by learning more about the local environment, and potential donations (Clarke, 1984; Knell & Taylor, 1989; Young, 1972).

Mr Martin Rickard donated his leopard tooth to the natural history collections at PCMAG. The evidence of the locality that the tooth was found, the strontium isotope analysis results and the radiocarbon dating indicate that it is highly likely this tooth was brought back from India by Linnaeus Tripe. This is an extremely important addition to the collections. The museum holds just 9 of Linnaeus Tripe's original glass plate negatives, with the V&A holding the rest of his photographs. This tooth is one of the rare natural history specimens collected by Linnaeus. The results of this joint investigation show how important museum enquiries are to adding to the collections, and how important, and successful, public participation in scientific research can be. Currently there have been no additional activities relating to the tooth.

After sharing the results, Mr Rickard was asked a few questions about the enquiry and the researched that stemmed from it. He commented that he felt part of the investigations, and enjoyed assisting in this exciting research: he was extremely impressed with how much we found out with the chemical analysis on the tooth. He has always been interested with local history and a keen desire to know more, otherwise he wouldn't have brought the tooth in. Mr Rickard liked the personal satisfaction of knowing what this tooth was and where (it most likely) had come from. He was aware of the cave sites at Cattedown and Oreston, and knew about cave lions and cave bears in Plymouth, but he didn't make the connection until he visited the museum. Mr Rickard had learnt more about his home than he thought: The family had always assumed that the tooth had come from the large Victorian cottage, Penlee Cottage, next door to his current house. However, spending time at the Local Studies Library, he discovered that his house actually lay on the grounds of the estate that belonged to The Elms (**Figure 4**). Mr Rickard also enjoyed learning about Dr Lorenzo Metham; he had heard of the Tripes, but not of Dr Metham. Interestingly, Mr Rickard later commented that whilst researching Metham, he had thought that he would have been the sort of person to have known other naturalists (like Worth) and specimens could have easily passed hands: completely independently, Mr Rickard had similar ideas which had sparked this investigation off originally. From just one enquiry, we had discovered a very possible reason for the tooth being in the garden supported by real science.

7. Conclusions

This upper canine was identified as belonging to a leopard (*Panthera pardus*). Social media assisted in determining the best method to work out where this tooth originated from, and we used strontium isotope analysis. The ^{87}Sr / ^{86}Sr isotope analysis gave a value of 0.71613, which was much higher than British records. The radiocarbon measurement of 187 ± 24 years indicated that this was not a Pleistocene leopard tooth, but a much more recent one. Mr Rickard's research into the history of the site where the tooth was discovered linked closely to Linnaeus Tripe who travelled extensively across India and Burma, strongly suggesting that the tooth was originally from an Indian or Burmese leopard. It is unknown if the tooth had originally belonged to a taxidermy leopard, or a leopard skin rug as nothing else was found associated with the tooth. Further DNA research could be carried out to identify the sub-species of leopard the tooth belonged to which could subsequently provide a location for the tooth. The collaborative research undertaken by the authors and a member of the public has unlocked the fascinating, rich history of this single specimen.

For Mr Rickard this one tooth has even more history than Linnaeus Tripe and his travels through India. It has a very personal connection. Found when Mr Rickard's father was filling in an old path in the garden, the 'Tiger tooth' has been part of the family for over 55 years. Mr Rickard had returned home to Plymouth after living away for 30 years. Whilst going through drawers with old family memories, he saw the 'Tiger tooth': the tooth that amazed visitors and guests, and brought wonder to friends who came to see it. The tooth was not just a tooth. It has a story. This enquiry was much more than a chemical analysis of an unknown tooth: it was empowering Mr Rickard to directly assist in discovering the origins of this tooth himself. From one museum enquiry we discovered a rich history. To paraphrase a famous quote; curiosity will find a way.

Competing Interests

The authors declare that they have no competing interests.

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