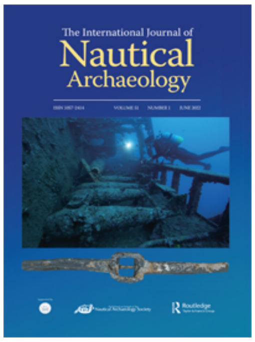

International Journal of Nautical Archaeology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rjna20

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To cite this article: Kimberly P. Kenyon, Rod Hatt, Trent M. Garrison & James C. Hower (2022): *Queen Anne's Revenge* Coal Conundrum: Origins of Coal Found in Association with a Historic Shipwreck, International Journal of Nautical Archaeology, DOI: 10.1080/10572414.2022.2101775

To link to this article: https://doi.org/10.1080/10572414.2022.2101775

INTERNATIONAL JOURNAL OF NAUTICAL ARCHAEOLOGY
https://doi.org/10.1080/10572414.2022.2101775

Queen Anne's Revenge Coal Conundrum: Origins of Coal Found in Association with a Historic Shipwreck

Kimberly P. Kenyon[a], Rod Hatt[b], Trent M. Garrison[c] and James C. Hower[d,e]

[a]Queen Anne's Revenge Conservation Laboratory, Office of State Archaeology, North Carolina Department of Natural and Cultural Resources, Greenville, NC, USA; [b]Coal Combustion, Inc., Versailles, KY, USA; [c]Kentucky Energy and Environment Cabinet, Frankfort, KY, USA; [d]University of Kentucky Center for Applied Energy Research, Lexington, KY, USA; [e]Department of Earth & Environmental Sciences, University of Kentucky, Lexington, KY, USA

ABSTRACT
Coal associated with site 31CR314, *Queen Anne's Revenge/La Concorde* (1718) was investigated to identify a possible source. The coal ranges from low volatile bituminous, through anthracite, to meta-anthracite. Although the eastern US anthracite sources were not known at that time, several sources, including coalfields in Ireland and Portugal, match some of the coal ranks from the shipwreck. The wreck lies near Beaufort, North Carolina, where a coaling station was built by the United States Navy during the American Civil War. Pennsylvania anthracite was an important resource by the 1860s, making it a logical source of the coal from site 31CR314.

El enigma del carbón del *Queen Anne's Revenge*: Origen del carbón hallado en asociación a un pecio histórico

RESUMEN
El carbón asociado al sitio 31CR314, *Queen Anne's Revenge/La Concorde* (1718) fue investigado para encontrar su posible fuente. El carbón se ubica en un rango entre baja volatilidad bituminosa, antracita y meta-antracita. Aunque las fuentes de antracita del este de EE.UU. no se conocían en aquel entonces, múltiples fuentes, incluidos los campos de carbón en Irlanda y Portugal, coinciden con algunos rangos del carbón hallado en el naufragio. El pecio descansa cerca de Beaufort, Carolina del Norte, en dónde la US Navy (Marina naval estadounidense) construyó una estación de carbón durante la Guerra Civil (Norte)americana. La antracita de Pennsylvania fue un recurso importante hacia 1860, lo que hace de ésta una fuente lógica para el carbón del sitio 31CR314.

“安妮女王复仇号” 的煤炭之谜: 出水煤炭的起源与历史沉船的关联

摘要
遗址 31CR314 即 “安妮女王复仇号 ” / “ 协和号” (1718) 出水煤炭的调查是为确认其可能的来源地。这些煤炭包括低挥发性烟煤、无烟煤和高阶无烟煤。尽管当时在美国东部无已知的无烟煤矿源, 但其他几个产地包括爱尔兰和葡萄牙的煤田与沉船上的一些煤炭等级相匹配。该沉船位于北卡罗莱纳州博福特附近, 在美国内战期间, 美国海军在此处建有一装煤站。宾夕法尼亚的无烟煤在十九世纪六十年代是非常重要的资源, 这使其成为31CR314遗址中煤炭的一处合理来源。

“安妮女王複仇號”的煤炭之謎: 出水煤炭的起源與歷史沉船的關聯

摘要
遺址31CR314即“安妮女王複仇號”/“協和號”(1718)出水煤炭的調查是爲確認其可能的來源地。這些煤炭包括低揮發性煙煤、無煙煤和高階無煙煤。盡管當時在美國東部無已知的無煙煤礦源, 但其他幾個產地包括愛爾蘭和葡萄牙的煤田與沈船上的一些煤炭等級相匹配。該沈船位于北卡羅萊納州博福特附近, 在美國內戰期間, 美國海軍在此處建有一裝煤站。賓夕法尼亞的無煙煤在十九世紀六十年代是非常重要的資源, 這使其成爲31CR314遺址中煤炭的一處合理來源。

لغز الفحم في سَفينة ثأر الملكة آن : أصول الفحم الذي تم العثور عليه بالترابط مع حُطام سفينة تاريخي

المُستخلص
تمت أعمال البحث والتحقيق في الفحم المرتبط بموقع ٣١س ر ٣١٤ ثأر الملكة آن/لا كونكورد (١٧١٨) وذلك لتحديد مصدره المُحتمل. ويُذكر أن الفحم من البيتومين منخفض التطاير يتراوح من أنثراسايت إلى ميتا أنثراسايت. وعلى الرغم من أن مصادر الأنثراسايت في شرق الولايات المتحدة لم تكن معروفة في ذلك الوقت، إلا أن العديد من المصادر بما في ذلك حقول الفحم في أيرلندا والبرتغال تتطابق مع بعض صفوف الفحم في حُطام السفينة. ويقع حُطام السفينة بالقرب من بوفورت في شمال كارولينا حيث تم بناء محطة فحم من قِبل البحرية الأمريكية أثناء الحرب الأهلية الأمريكية. ومن الجدير بالذكر أن أنثراسايت بنسلفانيا كان موردا مهما بحلول ستينيات القرن التاسع عشر مما جعله مصدراً منطقياً للفحم من موقع ٣١س ر ٣١٤.

ARTICLE HISTORY
Received 21 August 2020
Accepted 11 May 2022

KEYWORDS
Queen Anne's Revenge; *La Concorde*; site 31CR314; North Carolina; anthracite; U.S. Navy

PALABRAS CLAVE
Queen Anne's Revenge; *La Concorde*; sitio 31CR314; Carolina del Norte; antracita; Marina de Estados

关键词
“安妮女王复仇号”, “协和号”, 31CR314遗址, 北卡罗莱纳州, 无烟煤, 美国海军

關鍵詞
安妮女王復仇號,「協和號」, 31CR314遺址, 北卡羅萊納州, 無煙煤, 美國海軍

الكلمات الدلالية
ثأر الملكة آن; لا كونكورد; موقع ٣١ س ر ٣١٤; شمال كارولينا; أنثراسايت; البحرية الأمريكية

CONTACT Kimberly P. Kenyon kimberly.kenyon@ncdcr.gov Queen Anne's Revenge Conservation Laboratory, Office of State Archaeology, North Carolina Department of Natural and Cultural Resources, 1157 VOA Site C Road, Greenville, NC 27834, USA

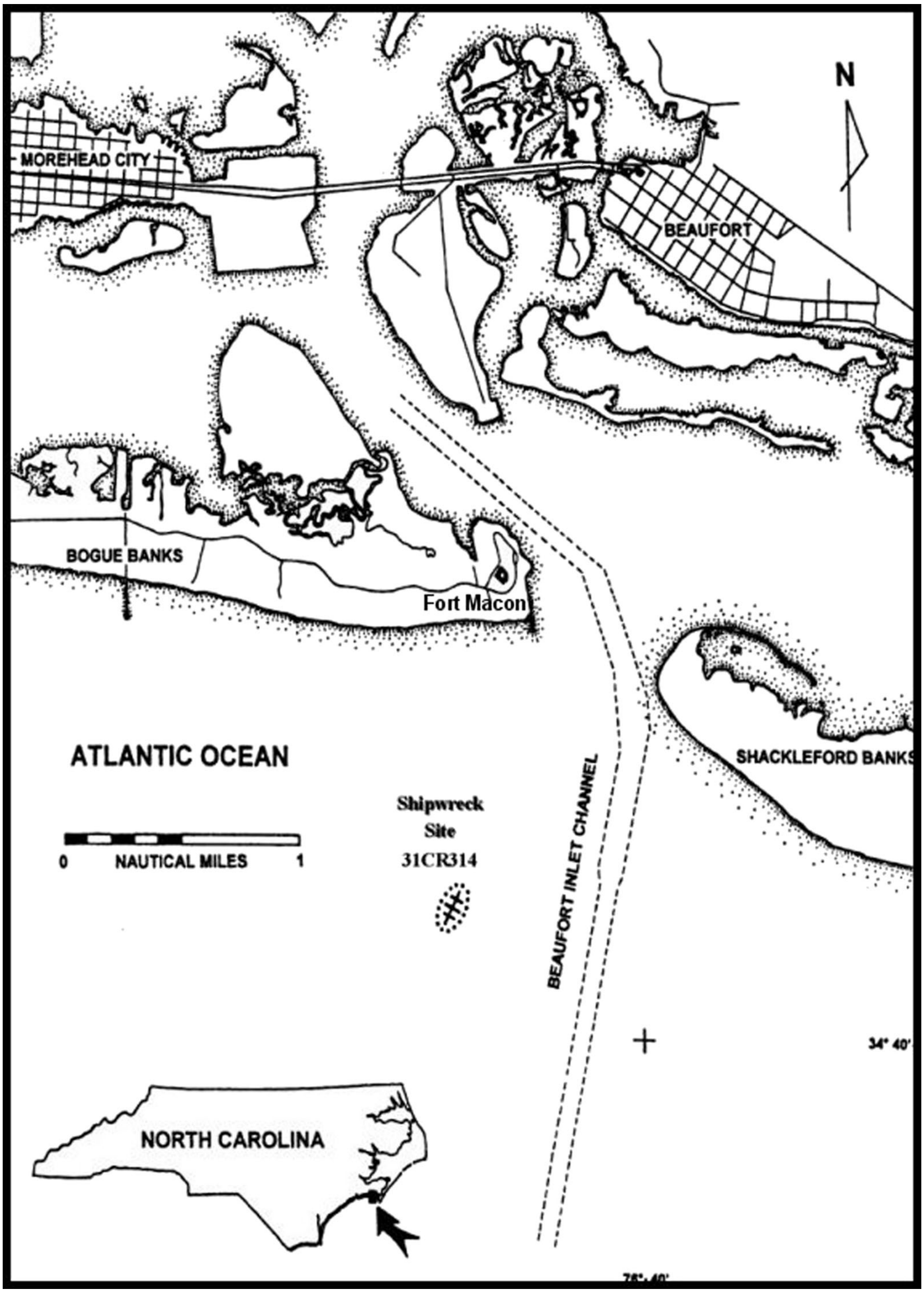

Figure 1. Location of Beaufort, Fort Macon, and site 31CR314 in North Carolina. (Image by NC Department of Natural and Cultural Resources).

North Carolina state archaeological site 31CR314, offshore Carteret County (Figure 1), has produced over 400,000 artefacts[1] since its discovery in 1996. Due to its location, the date of the artefacts, the nature of the assemblage, and the estimated size of the shipwreck, the site has been identified as the remains of Blackbeard's flagship, *Queen Anne's Revenge* (Wilde-Ramsing & Ewen, 2012). Excavation and research into the material culture are directed by co-principal investigators Kimberly Kenyon and Chris Southerly under the auspices of the Underwater Archaeology Branch of the North Carolina Office of State Archaeology within the North Carolina Department of Natural and Cultural Resources.

Prior to its brief and ill-fated stint as a pirate ship, the vessel was launched as a privateer in 1710 before entering the service of the slave trade (Wilde-Ramsing, 2009). Known at that time as *La Concorde*, the ship embarked on three transatlantic slaving voyages under the ownership of the prolific French merchant, René Montaudoin, with the third and final voyage departing Nantes in March 1717 (Moore & Daniel, 2001). The ship arrived in Whydah (present-day Benin) in July, taking on 516 captive Africans before embarking on its Middle Passage voyage to the Caribbean (Dosset, 1718; Ernaud, 1718). On 28 November 1717, near Martinique, a band of pirates intercepted *La Concorde* (Ernaud, 1718). Among them was Edward Thatch (also spelled as Teach), alias Blackbeard, who dubbed his new prize *Queen Anne's Revenge (QAR)* presumably in honour of the monarch he served in a previous life as a privateer (Johnson, 1724, pp. 70–90).

Following the ship's seizure, Blackbeard continued taking prizes in the Caribbean, amassing a fleet a crew of 300–400 pirates, and a wealth of goods. In May 1718, the pirates famously laid siege to Charleston, South Carolina, blockading the harbour in exchange for medicine and gold. The ship ran aground on a sandbar in early June while attempting to sail into Topsail Inlet (present-day Beaufort Inlet) and was abandoned, effectively putting an end to the ship's piratical career (Wilde-Ramsing, 2009).

Material and Methods

Disposition of Coal on Site 31CR314

Approximately half the site has been excavated and recovered, respective to the known footprint of the shipwreck and the projected boundary of the artefact scatter. Four hundred forty-nine individual examples of coal have been recovered through two different means: 413 specimens are defined as loose finds from the sediment, and 36 were discovered bound in iron concretions.

While discrete artefacts are mapped and raised individually, the sediment contains micro-artefacts which might otherwise escape the divers' notice, due in most part to poor visibility. Water-induction dredges are used to collect sediment in each 5 foot × 5 foot (1.524 m x 1.524 m) unit square until reaching an artefact-sterile layer. The efficacy of this method on the *QAR* site has been well documented (Price, 2016), with finds including gold grains, mercury, glass trade beads, copper-alloy sewing pins, and a multitude of lead shot. Provenience for artefacts from dredge spoil is recorded in reference to the southeast coordinates of the unit square from which the sediment was removed. Over 245,000 artefacts have been recovered using this method, including 380 pieces of coal. Twenty-one additional examples of coal were discovered and mapped *in situ* as discrete finds, and 12 were raised with ballast and later identified as coal. Ballast is batch-collected per unit square, which is then documented on shore where incidental material is separated and assigned a unique artefact number.

As iron corrodes in seawater, it develops a thick concretion layer which readily engulfs nearby objects as it expands. In addition to iron, it is common to find other metals, siliceous material, and organic matter embedded in this matrix. While two examples of concretion-bound coal have yet to be explored, photos and insights recorded by conservators reveal that 19 are only superficially attached to concretions. The remaining 15 either have only tentative identifications as coal or lack sufficient records to determine their original disposition within the concretion. While all concretions are X-rayed prior to conservation, coal may not be revealed during radiography due to the settings necessary to penetrate the thick concretion; thus, there may be additional coal samples awaiting discovery and future analysis. Four hundred eighty of the nearly 3200 iron concretions recovered have now been dismantled and their contents (over 36,000 artefacts) fully documented.

Coal is found evenly distributed across the site, with small pockets of higher concentrations (Figure 2). The units to the south-west and east of the site plan are largely devoid of other archaeological material. It should be noted that the units to the north of the site have yet to be fully excavated, hence the dearth of artefacts depicted here. In 2011, co-author Hatt selected four coal samples (QAR402.003.01, QAR1125.000.01, QAR3076.000.01, and QAR3400.002) for further chemical and petrographic analysis, assigning them new sample numbers (CCA01-04, respectively) for ease of reference. CCA-01 was batch collected with ballast from Unit 265, CCA-02 and CCA-03 were mapped and recovered as discrete finds, and CCA-04 was recovered in dredge spoil from Unit 226.

Coal Petrology and Chemistry Methods

Coal petrology was conducted on coarsely ground (generally <1 mm) coal from the coal pieces collected from discrete locations within and in the vicinity of the shipwreck. All petrographic work was conducted in the Applied Petrology Laboratory at the University of Kentucky Centre for Applied Energy Research. Macerals, the microscopic organic components of the coal, were identified based on discussions published by the International Committee for Coal and Organic Petrology (1998; 2001) and in Taylor et al. (1998). The particles were mounted in epoxy in 38-mm diameter moulds and prepared to a final 0.05-micron polish. Vitrinite reflectance analysis and maceral counts were done on Leitz Orthoplan microscopes equipped with oil-immersion, reflected-light 50x objectives. The vitrinite reflectance, a measure of the coal rank, was measured on the reflected light passing through a 548-nm bandpass filter to a photomultiplier. Standardization of the signal was done with a series of mounted glass standards of known reflectance. Coal chemistry, consisting of the proximate, ultimate, and heating value analyses, was contracted to Mineral Labs Inc., Salyersville, Kentucky.

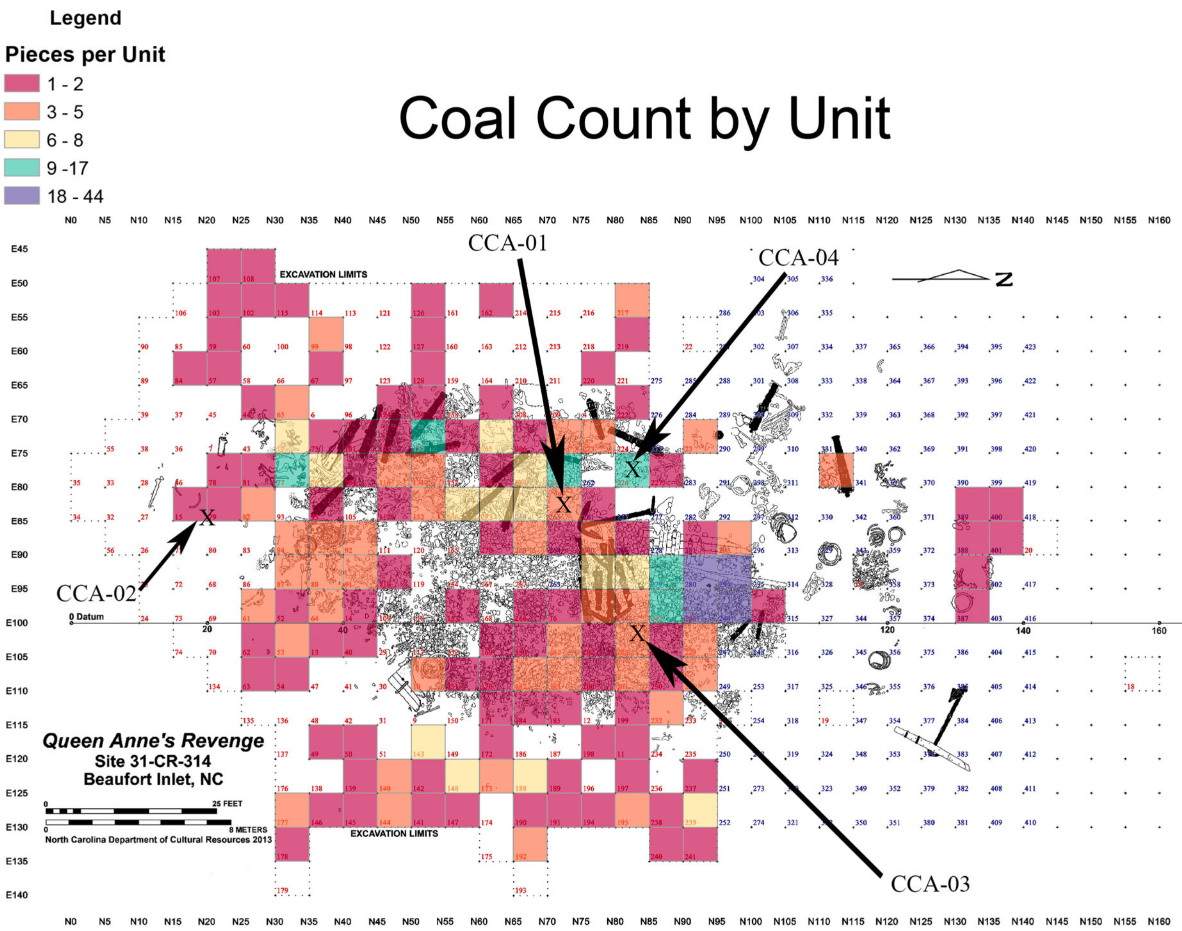

Figure 2. Distribution and concentration of coal per unit, with 'x' denoting site locations for CCA-01-CCA-04. (Image by NC Department of Natural and Cultural Resources, 2020).

Results and Discussion

Coal Chemistry and Petrology

The rank, the measure of the degree of metamorphism, of the selected coal samples is indicated by their proximate and ultimate analysis (Table 1) and by their vitrinite reflectance (Table 2). The four coal samples vary widely in their rank, with CCA-01 being a low volatile bituminous coal (maximum vitrinite reflectance = R_{max} = 1.68); CCA-02 and CCA-03 being anthracites; and CCA-04, with an R_{max} = 7.50, possibly being a meta-anthracite.

The low volatile bituminous CCA-01 is a relatively high inertinite coal with equal amounts of fusinite and semifusinite (Table 2). Assemblages include vitrinite, sporinite, and inertinite (Figure 3a); secretinite (Figure 3b); secretinite and other inertinite (Figure 3c); and fusinite (Figure 3d). The latter fusinite passed through a stage of fungal and/or bacterial degradation prior to being charred to the high fusinite reflectance. Similar forms have been observed by Hower et al. (2011; 2013) and Dai et al. (2012).

Liptinite macerals are generally not recognized in anthracites because their random reflectance converges on the vitrinite reflectance, making them difficult to identify in non-polarized light (Hower et al., 1994). The latter authors pointed out that, while the random reflectance of anthracitic vitrinite and the liptinites might be the same, liptinites have a greater maximum and lesser minimum reflectance than the associated vitrinite, making it possible to identify them using polarized light and a wavelength

Table 1. QAR and CCA sample numbers; as-received moisture; dry ash, volatile matter, and fixed carbon (the latter by difference: FC = 100 – ash – VM); dry Carbon, Hydrogen, Nitrogen, total Sulfur, and Oxygen (by difference); and moist, ash-free calorific value in MJ/kg.

QAR No.	CCA No.	Mois. as. rec.	Ash dry	VM dry	FC dry	C dry	H dry	N dry	S dry	O dry	CV (MJ/kg) moist, ash-free
402.003.01	01	0.80	2.84	17.34	79.82	89.16	4.01	1.23	0.59	2.17	36.60
1125.000.01	02	3.56	7.78	5.14	87.08	85.15	2.42	1.17	0.62	2.86	34.58
3076.000.01	03	2.89	8.95	4.61	86.44	84.97	1.95	1.14	0.69	2.30	34.15
3400.002	04	0.24	7.69	0.46	91.85	86.40	<0.01	1.05	0.54	4.32	22.33

Table 2. Maceral composition and vitrinite maximum and random reflectances for the coals.

	CCA-01		CCA-02		CCA-03		CCA-04	
Telinite	3.0	3.0	18.6	19.3	15.0	15.2	9.0	9.2
collotelinite	25.2	25.2	67.2	69.7	63.0	63.8	71.6	72.9
total telovitrinite	***28.2***	***28.2***	***85.8***	***89.0***	***78.0***	***78.9***	***80.6***	***82.1***
vitrodetrinite	14.6	14.6	4.8	5.0	8.2	8.3	2.2	2.2
collodetrinite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total detrovitrinite	***14.6***	***14.6***	***4.8***	***5.0***	***8.2***	***8.3***	***2.2***	***2.2***
corpogelinite	1.0	1.0	0.8	0.8	3.2	3.2	1.6	1.6
gelinite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total gelovitrinite	***1.0***	***1.0***	***0.8***	***0.8***	***3.2***	***3.2***	***1.6***	***1.6***
total vitrinite	***43.8***	***43.8***	***91.4***	***94.8***	***89.4***	***90.5***	***84.4***	***85.9***
fusinite	26.2	26.2	3.2	3.3	6.6	6.7	12.8	13.0
semifusinite	26.2	26.2	1.0	1.0	0.4	0.4	0.0	0.0
micrinite	2.4	2.4	0.0	0.0	0.0	0.0	0.2	0.2
macrinite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
secretinite	0.2	0.2	0.2	0.2	2.4	2.4	0.4	0.4
funginite	0.0	0.0	t	t	0.0	0.0	0.0	0.0
inertodetrinite	0.2	0.2	0.0	0.0	0.0	0.0	0.4	0.4
total inertinite	***55.2***	***55.2***	***4.4***	***4.6***	***9.4***	***9.5***	***13.8***	***14.1***
sporinite	1.0	1.0	0.2	0.2	0.0	0.0	0.0	0.0
cutinite	0.0	0.0	0.4	0.4	0.0	0.0	0.0	0.0
resinite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
alginite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
liptodetrinite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
suberinite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
exsudatinite	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
total liptinite	***1.0***	***1.0***	***0.6***	***0.6***	***0.0***	***0.0***	***0.0***	***0.0***
silicate	0.0		3.4		1.0		1.4	
sulfide	0.0		0.0		0.2		0.2	
carbonate	0.0		0.2		0.0		0.0	
other	0.0		0.0		0.0		0.2	
total mineral	***0.0***		***3.6***		***1.2***		***1.8***	
R_{max}	1.68		5.01		5.67		9.00	
st. dev.	0.24		0.46		0.52		0.97	
R_{random}	1.50		4.15		4.77		7.33	
st. dev.	0.23		0.46		0.65		0.69	

plate, as with the sporinite in Figure 4a and b. At least in lower-reflectance (lower-rank) anthracites, inertinite macerals can be easily distinguished in reflectance and texture from the associated vitrinite (Figure 5a-e). This is not necessarily as easily discerned in the meta-anthracite-rank coals, such as CCA-04, where the distinction between vitrinite and inertinite was difficult to determine.

Anthracite-grade metamorphism and the accompanying deformation can lead to pronounced reflectance anisotropy (Hower et al., 1994), to the degree that the vitrinite reflectance ellipsoid (as defined by the orientations of the maximum, intermediate, and minimum reflectance axes) can be used as a tectonic fabric element (Hower & Davis, 1981; Levine & Davis, 1989a; 1989b). Within the anthracites, vitrinite exhibits striking reflectance anisotropy, both in normal banding and, in particular, when draped around less deformable inertinite. For example, the vitrinite surrounding the secretinite and inertodetrinite in Figure 6a shows a definite extinction pattern around the inertinite macerals. Similarly, the vitrinite surrounding the inertinite shard in Figure 6b shows varying degrees of extinction as it wraps around the inertinite. Similar deformation features are observed in lower rank coals, but the overall orientation of the vitrinite molecules is too random to show the degree of anisotropy seen in anthracites. The CCA-02 vitrinite (Figure 6c) does shows a slight degree of anisotropy surrounding the inertinite in the centre of the image. The latter inertinite might be funginite, but the identification is tentative, owing in part to the scarcity of such forms in high-rank and (presumably; see discussion below) Pennsylvanian coals. Some of the CCA-04 vitrinite shows signs of incipient graphitization, as seen in the sub-micron anisotropic-domain texture of the vitrinite (Figure 6d). Aside from the vitrinite reflectance anisotropy noted above, signs of deformation in the anthracites include annealing of fractures with organic material largely resembling the fractured coal (Figure 7a-b) and with coke (Figure 8a-b; and portions of the cementing in Figure 7a).

Possible Sources of the Coal

In a 19th- or 20th-century setting, the simplest explanation for the origin of the four coals would be relatively simple because both low volatile bituminous- and anthracite-rank coals have been mined in the Appalachians (Hower et al., 1993; 2019; Hower & Gayer, 2002; Ruppert et al., 2010). Low-volatile bituminous coals, similar in rank to CCA-01, are found in the Valley Fields along the upper reaches of the James River in west-central Virginia; parts of the Richmond Basin of central Virginia; the Cahaba basin, Alabama; western

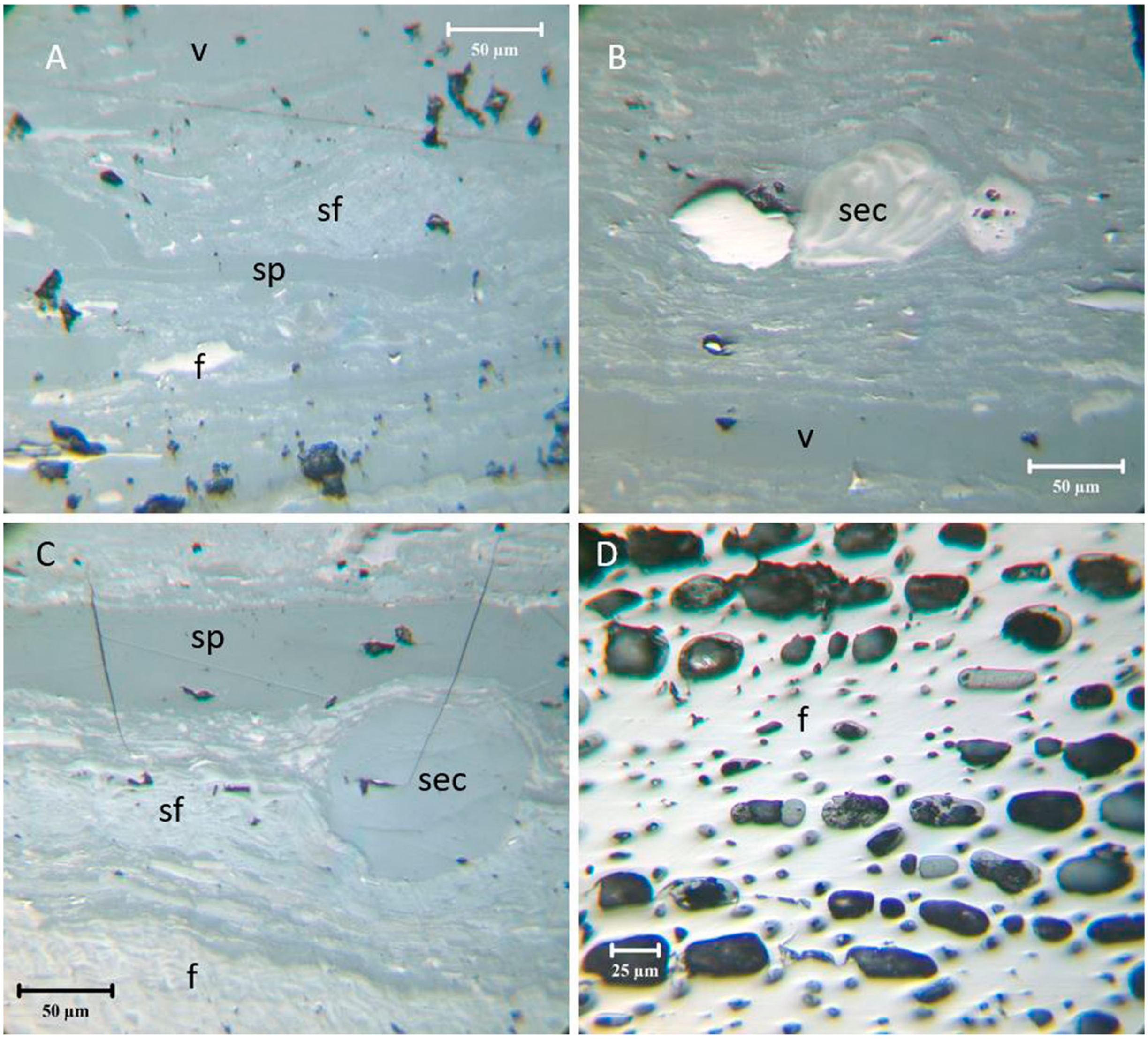

Figure 3. A. CCA-01 (image 02): Semifusinite [sf], fusinite [f], sporinite [sp], and vitrinite [v], scale = 50 µm. B. CCA-01 (image 07): Secretinite [sec] and vitrinite [v], scale = 50 µm. C. CCA-01 (image 09): Semifusinite [sf], fusinite [f], sporinite [sp], and secretinite [sec], scale = 50 µm. D. CCA01 (image 10): Fusinite [f], scale = 25 µm. (Images by James Hower, 2013).

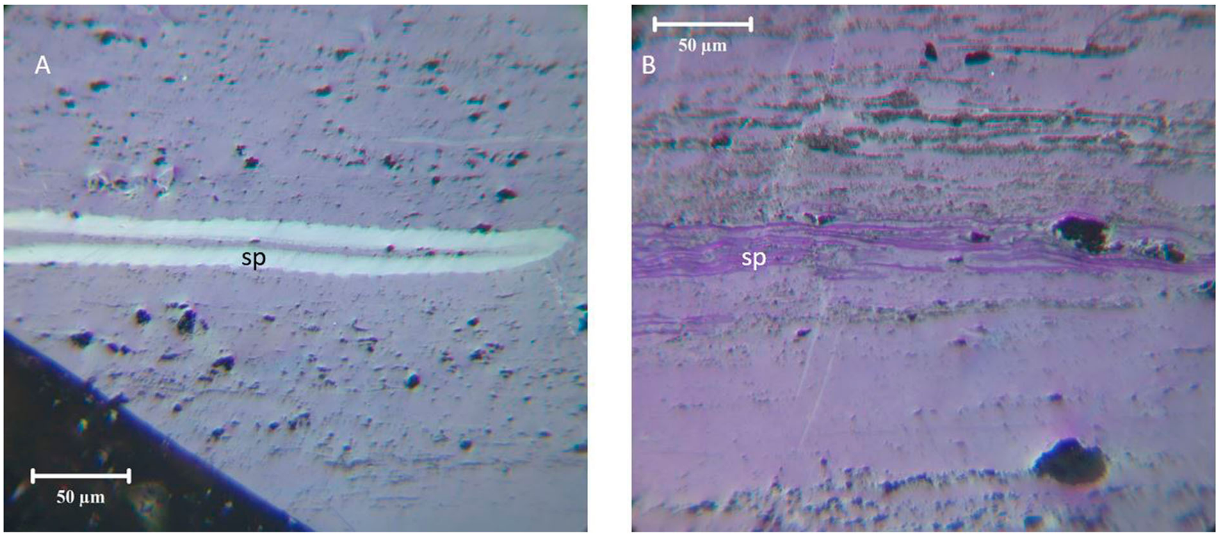

Figure 4. A. CCA-02 (image 25): Sporinite [sp], scale = 50 µm. B. CCA-02 (image 13): Sporinite [sp], scale = 50 µm. (Images by James Hower, 2013).

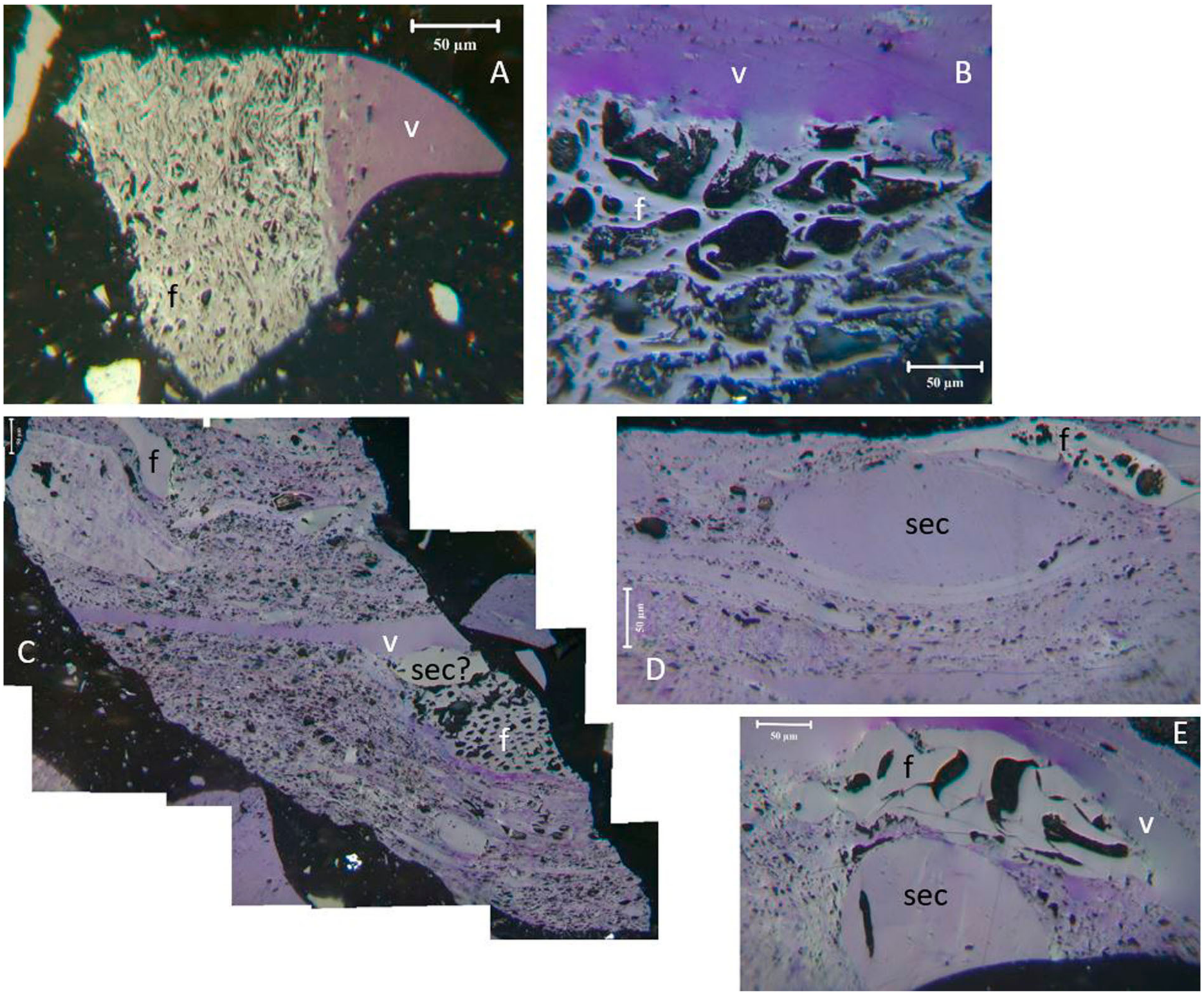

Figure 5. A. CCA-02 (image 08): Vitrinite [v] and fusinite[f], scale = 50 µm. B. CCA-02 (image 27): Vitrinite [v] and fusinite [f], scale = 50 µm. C. CCA-03 (image 06): Vitrinite [v], secretinite [sec], and fusinite [f], scale = 50 µm. D. CCA-03 (image 02): Secretinite [sec] and fusinite [f], scale = 50 µm. E. CCA-03 (image 03): Vitrinite [v], secretinite [sec], and fusinite [f], scale = 50 µm. (Images by James Hower, 2013).

Virginia and southern West Virginia; western Pennsylvania and adjacent parts of Maryland; the Broad Top coalfield in south-central Pennsylvania; and in the north-central fields of Pennsylvania (Hower et al., 2013; Lewis & Hower, 1990; Ruppert et al., 2010). The western Virginia/southern West Virginia and western Pennsylvania sources are readily available to points along the central Atlantic coast. None of these sources, however, with the possible exception of the Richmond Basin, was an early 18th-century coal source.

The Valley Fields also contain semi-anthracite-rank coal, but the reflectance is <3%R_{max}, much lower than the CCA anthracites. Pennsylvania anthracites, with many sources a good match in coal rank to CCA-02 and CCA-03 (Table 3), were not known to European settlers until the later 18th century. Narragansett Basin (Massachusetts and Rhode Island) anthracite was first mined in 1736 (Lyons & Chase, 1981).

CCA-04's meta-anthracite reflectance of 7.50% R_{max} is problematical. No sources of such high reflectance are known in the Pennsylvania Anthracite Fields, although modern petrographic studies post-dated the World War I peak of mining by more than 50 years, so it is possible that coals with reflectances greater than 6% R_{max}, the approximate upper limit based on post-1976 studies, could have been mined in the past. The Narragansett Basin coals, however, are known to reach high levels of metamorphism (Hower et al., 1993; Raben & Gray, 1979), with R_{max} up to 7.62%, and, in some cases, show coke and incipient coke textures. Some of the Triassic Richmond Basin coals also have been coked, with the adjacent coals showing elevated ranks (Hower, 2014). Among other basins surrounding the Atlantic Ocean, the South Wales anthracites do not reach the degree of metamorphism seen in the CCA coals (Hower & Gayer, 2002). The Douro, Portugal, coals, first mined in the later 18th century, attained the rank of the CCA anthracites (Ribeiro et al., 2010). Kinsale Harbour-Old Head of Kinsale, Ireland, coals have R_{random} values in the 4.06-5.21% range, with the R_{max} of the top 10% of the latter sample averaging 7.81% (Clayton, 1989). It is also possible that CCA-04 represents an anthracite that was heated, but not combusted, in a boiler.

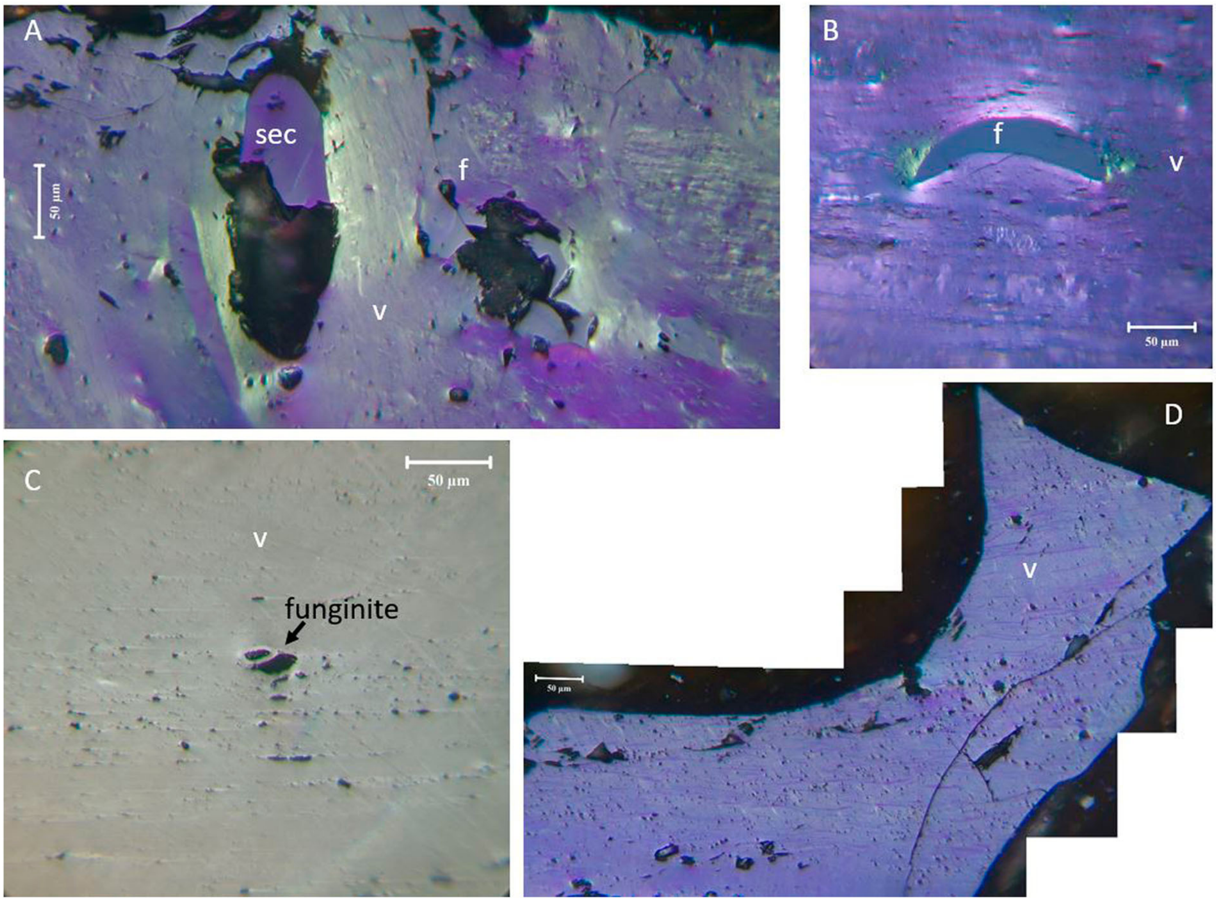

Figure 6. A. CCA-04 (image 07): Anisotropy in vitrinite [v] compressed between secretinite [sec] and fusinite [f], scale = 50 µm. B. CCA-03 (image 04): Anisotropy in vitrinite [v] wrapped around curved fusinite [f], scale = 50 µm. C. CCA-02 (image 15): Subtle anisotropy in vitrinite [v] surrounding inertinite, possible funginite, scale = 50 µm. D. CCA-04 (image 14): Incipient graphitization in vitrinite [v], scale = 50 µm. (Images by James Hower, 2013).

Site Distribution

In interpreting the presence of coal from NC site 31CR314, several factors deserve consideration. On a ship of a certain age, coal of course may serve many uses, as has been documented in the archaeological and historical records. However, it must be considered that the dynamic nature of the Beaufort Inlet ebb-tidal

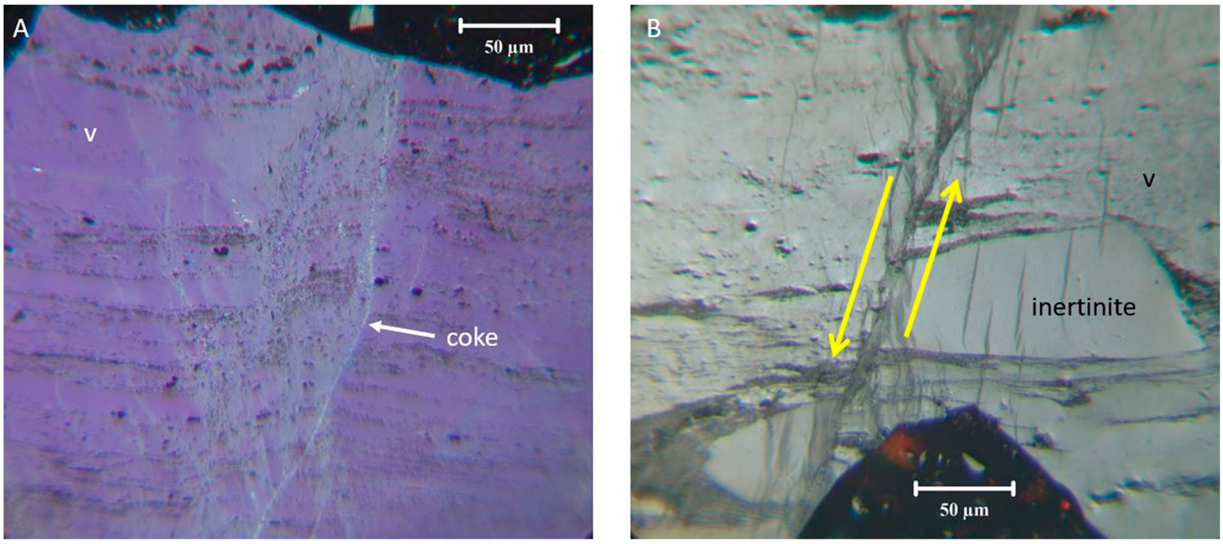

Figure 7. A. CCA-02 (image 21): Annealing of fractured vitrinite [v] with some coke in the fracture, scale = 50 µm. B. CCA-02 (image 07): Annealing of macerals in coal with vitrinite [v] and inertinite. Arrows mark the direction of the relative movement along the fracture, scale = 50 µm. (Images by James Hower, 2013).

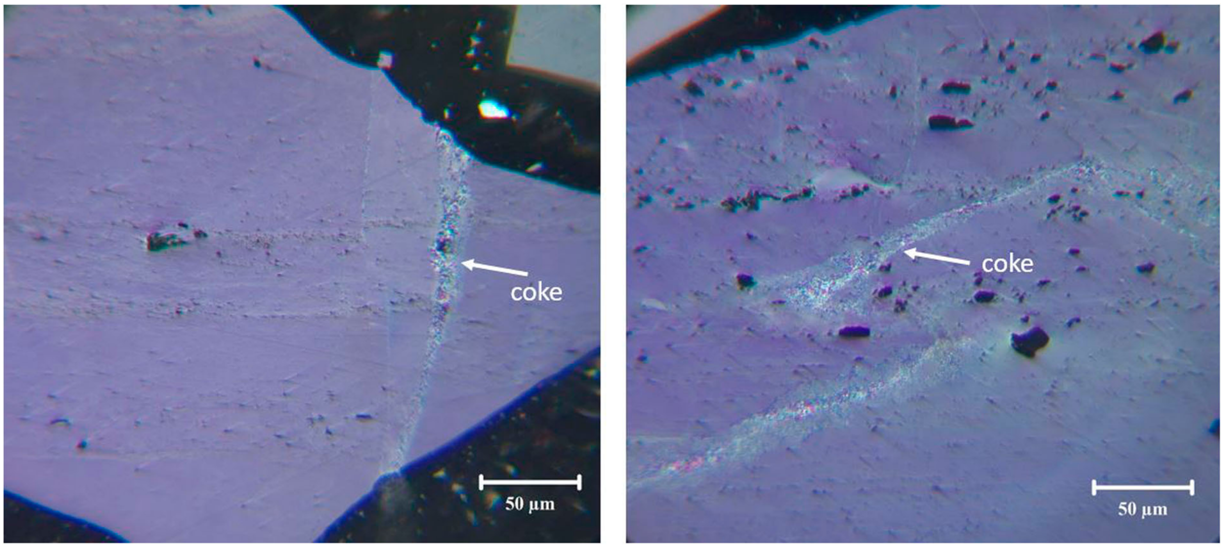

Figure 8. A. CCA-02 (image 17): Coke in fracture in vitrinite, scale = 50 µm. B. CCA-02 (image 19): Coke in fracture in vitrinite, scale = 50 µm. (Images by James Hower, 2013).

delta means that intrusive material occasionally finds its way onto site. This is evidenced by isolated 19th-century glass and ceramic finds and 20th-century coins, aluminium cans, soda bottles, and golf balls.

The scattering of the coal across the site is not typically the case with other artefacts dating to the 1718 grounding; they are predictably concentrated nearer to the wreck site proper. The area of highest coal concentration just north of the midships 'pile' of anchors and cannon is where routine scouring occurs, with significant removal of sediment observed in the wake of major storm events (Henry, 2000; McNinch et al., 2001). The pits which result in such scour regularly collect modern intrusive material and loose artefacts, due to the energetic environment in which they are deposited.

Since first charted in the 1700s, the navigable channel is known to have migrated, travelling near the site through most of the 18th and early 19th centuries and again beginning in the early 20th century (Wells & McNinch, 2001), allowing direct deposition of later objects by passers-by. Historically, there was also heavy industrial ship traffic in the area, which cannot be discounted as a source for the coal.

Archaeological Evidence for Coal as a Galley Fuel Source

While the exhaustive use of coal for propulsion did not begin until the 19th century, coal has been noted in several 17th- and 18th-century archaeological contexts as a source of fuel for cooking. Coal was found among galley items on the 1653 wreck of *Swan* (Martin, 2017), the 1717 *Whydah* shipwreck (Muncher, 1991), and the 1749 wreck of *L'Aimable Grenot* (L'Hour & Veyrat, 2002). Archaeologists excavating *Dartmouth* (1690) recorded coal among the debris within the galley context, alongside charred animal bones. Careful observation allowed for the distinction between intrusive coal from the nearby wreckage of a 1940s-era collier and coal determined to be part of the *Dartmouth* assemblage (Martin, 1978). Analysis of coal from *Bounty* (1789) provided evidence for possible uses in cooking and heating, or for use in the ship's forge (Erskine et al., 2008). There is no evidence to suggest these latter two activities occurred aboard *QAR*, and the only mention of fuel for cooking in the historical record is in the form of firewood; specifically, *La Concorde* stopped at Mesurade (present-day Liberia) to gather firewood on 6 June 1717, *en route* to Whydah (Ernaud, 1718). Firewood is also commonly found in galley contexts for wrecks of this period, such as the 1645 wreck of *Stora Sofia* (Bergstrand, 2009) and *Mynden* lost in 1718 (Auer, 2004), although none yet has been identified on site 31CR314.

The Beaufort Harbour Refuelling Station

Historic shipping activities in Beaufort Harbour offer another distinct possibility for the source of coal on the *QAR* wreck site. Despite offering the best port in the state, Beaufort remained a quiet hamlet with an underutilized deep port until the Union occupation in the U.S. Civil War. The swampy terrain made it difficult for goods to travel over land, thus, the small town was effectively isolated from the interior until the mid-19th century. As Wilmington's (North Carolina) importance rose by 1840, the citizens of Carteret County appealed for an improved overland route by rail to take advantage of Beaufort's deeper harbour and hopefully bring more prosperity to the town. However, since Beaufort lacked infrastructure and existing commerce, a railroad terminus was

Table 3. Pennsylvania anthracite samples from the Penn State Office of Coal database with similar coal rank to CCA-02 and CCA-03.

PSOC No.	"similar" CCA No.	Ash dry	VM dry	FC dry	FC dry, ash-free	S dry	CV (MJ/kg) moist, ash-free	R_{max}
81	02	7.84	5.65	86.52	86.52	0.50	34.68	5.10
872	02	3.63	3.49	92.88	92.88	0.39	34.77	5.11
873	02	11.86	3.55	84.59	84.59	0.81	34.27	5.25
1558	02	11.15	4.51	84.34	84.34	0.50	34.78	5.19
867	03	13.91	3.71	82.38	82.38	0.52	33.94	5.77
868	03	25.99	4.22	69.79	69.79	0.60	33.81	5.85
869	03	11.36	3.43	85.21	85.21	0.48	33.81	5.73
870	03	2.56	3.05	94.39	94.39	0.50	34.54	5.57

established at Morehead City, just short of Beaufort, in 1860 (Browning, 2011).

Following the capture by of Fort Macon near Beaufort on 26 April 1862, by Union troops, Beaufort Harbour became an invaluable Union coal refuelling station. With the blockade of Southern ports well under way, the Union had eagerly awaited the seizure of the city, recognizing its potential as a strategic base. The Union urgently needed refuelling stations to maintain the blockade, and Beaufort would play a pivotal role in resupplying vessels charged with the blockade of Wilmington. The first shipment of coal arrived by sea from Philadelphia on 12 May 1862. As operations became more regulated, it was ordered that at least 1000 tons of coal be kept on hand. By 1864, 27 ships consuming 2000 tons of coal per month were engaged in the blockade of Wilmington, with additional vessels guarding smaller rivers and inlets, all of which depended on Beaufort for fuel. Beaufort's significance as a coaling station is clear; by 1864 the value of its naval stores, including over 8000 tons of coal, nearly surpassed that of the Baltimore and Washington stores combined. From 1862–1864, 421 vessels made 484 trips into Beaufort for refuelling (Blair, 2002). The naval station at Beaufort was short-lived. With the fall of Fort Fisher on the Cape Fear Peninsula, south of Wilmington, and the closure of Wilmington in early 1865, the need for naval stores in the area came to an end, and the Beaufort Harbour refuelling station was closed.

A mid- to late-19th-century source of anthracite from Pennsylvania is logical, both because the US Navy would have preferentially purchased US coal[2] and also because the Pennsylvania coalfields dominated both world and US coal production in that era. In 1897, for example, Pennsylvania produced over 107 Mt almost equally split between the bituminous and anthracite fields; this represented 53% of US coal production and over one-sixth of the worldwide coal production (Pennsylvania Bureau of Mines, 1898). In addition, CCA-02 and CCA-03 closely match well-studied samples from the Pennsylvania Anthracite Fields (Table 3). Co-author Hower collected the PSOC samples in the 800 range in 1977.

Conclusion

Examination of coal from North Carolina archaeological site 31CR314 indicates that the coal post-dates the grounding of *Queen Anne's Revenge/La Concorde*. Unlike other contemporaneous sites, no coal from site 31CR314 can be directly associated with the 1718 assemblage. Petrographic and chemical analysis of individual specimens and the manner of its discovery, loose in the debris field with the occasional superficial attachment to concretions, indicate that the coal is a more recent intrusion. The even distribution of coal finds, including regular discoveries of coal outside of the main wreck footprint, also suggests later deposits. Outlying units do not produce regular patterns of artefacts dating to the 1718 grounding; thus, spatial analysis of the coal reinforces the notion of its later deposition. The prominent role Beaufort played as a refuelling station during the US Civil War and the steady transportation of coal in and out of Beaufort Harbour during the Union occupation account for its presence on site.

Notes

1. Artefacts of the same type from the same context are grouped together under one artefact number, called a QAR number. There are over 11,000 assigned QAR numbers representing the total artefact count. For the purposes of this paper, the total count is used.
2. Such arrangements continued into more recent times. Pennsylvania Congressman Daniel Flood introduced measures requiring US Army bases in Germany to use Pennsylvania anthracite and prohibiting their use of fuel oil (Miller & Sharpless, 1985, p. 327).

Acknowledgements

Analysis of spatial data would not have been possible without the Office of State Archaeology's GIS Specialist Sam Franklin and QAR Lab Manager Elise Carroll, who contributed many hours in processing site data to produce an artefact distribution map to support this research. The QAR

conservation team, both past and present, continue to demonstrate the utmost care and precision in documenting and conserving the collection.

Author Contributions

Study design: All authors. Fieldwork: Kimberly Kenyon. Petrological and chemical analysis: James Hower, Trent Garrison, and Rod Hatt. Data interpretation: All authors. Manuscript writing: Kimberly Kenyon and James Hower. Comments on the manuscript: All authors.

Permission Statement

Excavation and research into the material culture were carried out under the auspices of the Underwater Archaeology Branch of the North Carolina Office of State Archaeology within the North Carolina Department of Natural and Cultural Resources. Data and material from shipwreck 31CR314 reside in the custody of the North Carolina Department of Natural and Cultural Resources. The first author is employed by this agency and serves as a custodian of the data with the collection under her direct care.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

ORCID

Kimberly P. Kenyon http://orcid.org/0000-0002-1448-1568

James C. Hower http://orcid.org/0000-0003-4694-2776

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