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Lithic networks reveal early regionalization in late Pleistocene North America

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ABSTRACT

North America was colonized by hunter–gatherer populations during the late Pleistocene, and the Clovis culture is the earliest well-documented evidence of this event. Long-standing questions about the colonization process persist, including the extent to which low-density populations maintained contact across the continent and if foraging territories overlapped or were spatially-discrete. Here, we use a network approach to examine the spatial structure of land use associated with the earliest hunter–gatherer populations in North America. In particular, we examine the co-occurrence of raw materials used for stone tool manufacture at archaeological sites across the continent. Using a database of 84 Clovis assemblages we show that there are three large isolated, mostly spatially-discrete, lithic exploitation networks across the continent. These regions closely correspond to previously identified differences in Clovis point form, suggesting that Clovis populations were becoming regionally distinct. This process of cultural diversification that begins in the late Pleistocene, continues to develop into the Holocene.

1. Introduction

North America was colonized by hunter–gatherer populations sometime during the late Pleistocene (Barton et al., 2004; Bradley et al., 2010; Goebel et al., 2008; Haynes, 2002; Kitchen et al., 2008; Meltzer, 2009; Rasmussen et al., 2014; Reich et al., 2012; Smallwood and Jennings, 2015; Tamm et al., 2007; Waters et al., 2011). The most complete archaeological record associated with the colonization is the well-known Clovis culture found throughout much of North America, dating to between approximately 13,400 to 12,500 calendar years before present (Haynes et al., 1984, 2007; Sanchez et al., 2014; Waters and Stafford, 2007). However, recent evidence suggests that people may have first arrived on the continent as early as 15,000 years ago (Goebel et al., 2008; Waters et al., 2011). Whatever the timing of the initial colonization event, the archaeological record and genetic diversity data suggest that densities in these earliest populations were low across the continent compared to population levels of subsequent millennia (Bocquet-Appel, 1985; Goebel et al., 2008; O'Rourke and Raff, 2010; Peros et al., 2010; Surovell, 2000; Tamm et al., 2007). A long-standing question concerning the colonization process is the extent to which the first peoples in North America maintained social interactions over large geographic areas given their low population densities (Anderson, 1990, 1995; Anderson and Gillam, 2000, 2001; Meltzer, 2004), and whether these social interactions resulted in the regionalization and diversification of Clovis subpopulations across the continent.

Here, using network analysis of distinct raw materials in 84 Clovis assemblages we examine the structure of stone tool raw material use across the late Pleistocene landscape. We use shared stone raw material occurrences in artifact assemblages from sites to: 1) show which assemblages have shared raw materials among geographically separated sites; and 2) evaluate the presence or absence of regional boundaries in raw material use and their spatial scale. Our expectation is that if Clovis subpopulations were regionally bounded by knowledge of local environments we would

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see spatially-discrete lithic regions across the continent. Archaeologically, these regions would be observed as non-overlapping networks of the shared use of multiple stone raw materials within distinct regional boundaries. On the other hand, if Clovis subpopulations simply used local raw materials available within the radius of their foraging territories, then shared raw material use would overlap continuously at a local scale resulting in a lack of distinct regional boundaries in raw material use at the continental scale. The former finding would be consistent with models suggesting large-scale regional adaptations (Anderson, 1990, 1995; Anderson and Gillam, 2000, 2001; Goebel et al., 2008; Miller et al., 2014; Meltzer, 2004, 2009). The latter finding would be consistent with colonization models suggesting a rapidly moving, wide-ranging population with little or no regional adaptations (Haynes, 1964; Kelly and Todd, 1988).

Network analysis of lithic raw materials has been used successfully by archaeologists in different temporal and geographic settings (e.g., Golitko et al., 2012; Golitko and Feinman, 2015; Mills et al., 2013; Phillips, 2011). This approach offers a set of methods for analyzing and visualizing the interconnection of datasets. Here, we apply similar methods to examine Clovis regionality using stone tools and flaking debris made of distinctive raw materials recovered at Clovis sites. We used the co-occurrence of distinctive stone raw materials in Clovis assemblages to evaluate the structure, properties, and scale of Clovis lithic regionality. In the following network analysis archaeological assemblages are the nodes, and co-occurrences of distinct stone raw materials between assemblages are edges. The networks are binary with symmetric, undirected edges. We employed the spring embedding method using geodesic distances, node repulsion, and equal edge length as the layout criteria to visualize the networks. Our analyses proceeded by first identifying the number of components and isolates in the overall sample of nodes. We then used several measures of network structure to describe the overall network and to compare the structures of the various components within the overall network.

2. Materials and methods

2.1. Materials

We generated data from Clovis lithic assemblages for our analyses. An assemblage had to meet three criteria to be included in the study. First, it had to be reliably dated to the Clovis period, meaning that it either was associated with radiometric dates in the ca. 13,400–12,800 calBP range in the West and ca. 12,800–12,500 calBP range in the East (Gingerich, 2011; Haynes et al., 1984, 2007; Holliday, 2000; Levine, 1990; Miller and Gingerich, 2013; Sanchez et al., 2014; Waters and Stafford, 2007) or contained diagnostic artifacts that are radiometrically dated to these age ranges at another site. We used different age ranges for Clovis in the West and East because Clovis appears to be time-transgressive in that a diffusion process began in the West around 13,400 calBP and ended in the Northeast by 12,500 calBP (Hamilton and Buchanan, 2007). Second, chronologically diagnostic artifacts in an assemblage had to be restricted to those about which there is general agreement that they were produced only during the Clovis period. Third, an assemblage had to be available for study or information concerning raw material sources represented in the assemblage had to be published.

We examined a total of 84 lithic assemblages. The entire list of lithic raw materials for each assemblage can be found in Supplementary Table 1. In terms of regional coverage, our sample spans from Washington State to Nova Scotia and Wisconsin to Texas. We do not have assemblages from large portions of the American Far West (California, Oregon, Nevada, and Utah) or portions of the Southeast (Florida, Alabama, and Mississippi). Both areas have assemblages that are thought to date to the Early Paleoindian period (e.g.,Beck and Jones, 1997, 2010; O'Brien et al., 2001, 2014; Willig, 1991), but at the time the data were collected, neither region had an assemblage that met the criteria for inclusion in the study.

The identification of raw material types and sources of stone artifacts in our sample was based on first-hand visual examinations by the authors or taken from the published literature. Several studies using trace element analysis to verify the source locations of Clovis artifacts have been carried out and we included these results where possible (e.g., Burke, 2006; Hoard et al., 1992; Huckell et al., 2011). Further research will benefit from using quantitative evidence from trace element analysis as it is needed to verify some of the source attributions made solely through visual inspection (e.g., Boulanger et al., 2015). Our sample of lithics from the 84 Clovis assemblages consists primarily of cryptocrystalline sedimentary rocks, including various forms of chert, agate, jasper, flint, and chalcedony. Of the 241 observations of raw material types recorded in the lithic assemblages, cryptocrystalline sedimentary rocks occurred most often (85.2%). The next most common raw material types in the sample are obsidian and rhyolite, both occurring eight times (3.2%). Other raw material types that are represented in low proportions are quartzite (2.8%), quartz (2%), felsite (0.8%), silicified limestone (0.8%), silicified wood (0.8%), porcellanite (0.4%), argillite (0.4%), and siltstone (0.4%). Cryptocrystalline sedimentary rocks, obsidian, and rhyolite are generally considered high-quality raw materials that are easily worked by flintknappers (Buchanan and Collard, 2010; Eren et al., 2014). The abundance of high-quality raw materials in the Clovis lithic assemblages (91.6%) suggests that the selection of high-quality raw materials extended to all aspects of Clovis lithic tool manufacture. This finding is consistent with the long-held notion that Clovis flintknappers relied on high-quality raw materials to make their stone tools (Goodyear, 1989; Haynes, 1980; Kelly and Todd, 1988).

Many of the raw material types observed in the Clovis assemblages in our sample could be attributed to specific, well-known geological sources. A total of 101 distinct raw material sources are represented in the assemblages. The most commonly observed raw material source was Onondaga chert, which occurred at 15 Clovis sites, followed by Normanskill chert and Vera Cruz area jasper, both occurring at 14 Clovis sites. Edwards and Upper Mercer cherts were also common among sites occurring at 13 and 10 sites, respectively. The remaining raw material sources are represented in less than 10 assemblages each. The five geological sources that occur at 10 or more Clovis sites are spatially extensive and occur mostly in the East (Onondoga, Normanskill, Vera Cruz, and Upper Mercer), but one source occurs in the West (Edwards). A large number ($n = 62$) of raw material sources are represented only in single assemblages and thus do not factor in the network analyses. These unique raw material sources are near evenly distributed between the West ($n = 30$) and the East ($n = 32$) regions of the continent[1]. This distribution indicates that the use of unique sources is not biased by region and foragers were using lithic sources in a similar way in the West and East.

2.2. Network methods

We used the identified sources of stone raw materials represented in our sample of 84 Clovis lithic assemblages to construct networks. Assemblages were designated as nodes in our analyses with shared stone raw materials between nodes connected by edges or ties. The Clovis lithic networks are binary with symmetric, undirected ties among nodes having similar stone raw materials. We constructed network graphs using the layout procedure in