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People, Societies, and Landscapes

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the phase difference between incoming and outgoing quasiparticle waves.

Hanaguri *et al*. applied a magnetic field to introduce a new type of sign-changing scattering center, a superconducting magnetic vortex. As the magnetic field was increased, the quasiparticle scattering was increasingly dominated by these vortices. An increase in the amplitude of interference between quasiparticles from the two different Fermi surfaces was seen relative to interference between quasiparticles from the same Fermi surface, showing that the two different Fermi surfaces must have opposite sign.

High-T_c superconductor research has focused both on fundamental understanding and on practical applications. Thus, it is ironic that the magnetic vortices used to better understand high-T_c superconductivity are also the primary impediment to applications due to their unwanted dissipative motion when current is applied. So far, the vortices appear to be well-pinned in iron-based superconductors (*15*), but T_c has maxed out at 57 K. However, the recent evidence (*2*, *3*) establishing the spin-mediation as a leading candidate for the pairing mechanism that operates across the major families of high-T_c iron-based superconductors also provides insight into the mechanism of cuprate superconductivity. This result also suggests a promising avenue in the search for higher T_c materials—look for materials with similar band structures that undergo magnetic interactions (*5*).

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ARCHAEOLOGY

People, Societies, and Landscapes

Sophisticated geographical models are aiding archaeological research into how people have used and altered local landscapes.

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Ever since humans domesticated plants and animals, they have wielded the potential to substantially change the shape of the landscape. But more often than not, landscape change is driven not just by human activity but also by underlying factors such as climate and soil type. In the long-term interactions among people, society, and landscape, any one factor—including climate—may be responsible for tipping a system into instability. Archaeologists increasingly use advanced geographical modeling techniques to unravel these complex interactions at a community or farmstead scale (*1*–*4*).

Conventional archaeological field surveys typically provide very detailed local information, but it can be difficult to interpret these "point finds" within a larger context. Today, archaeologists use a wide range of multidisciplinary scientific techniques to investigate human-landscape interactions. Transects across and through buried landscapes are examined for their past soil and vegetation records and are combined with the spatial organizational data from the archaeological record to give detailed sequences of human intervention in the landscape (*5*, *6*).

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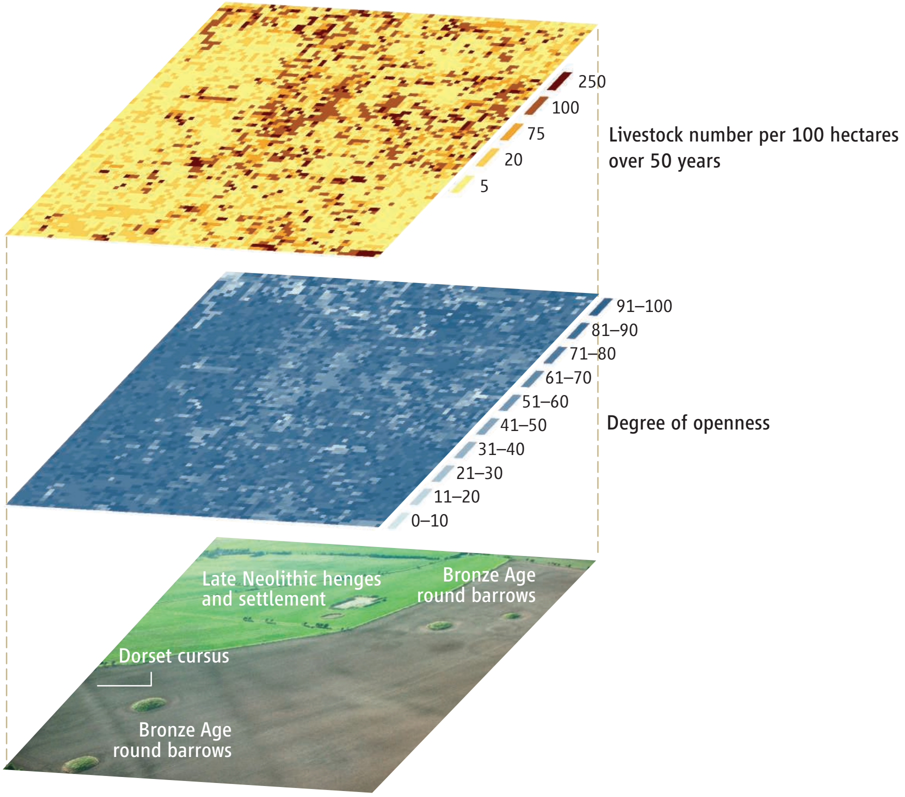
For example, in the Aguas Valley in southeast Spain, investigations using this suite of methods indicated that the advent of metalwork production with associated intensive wheat cultivation in the third millennium B.C.E. led to the start of widespread erosion, affecting the hill slopes and filling the wide alluvial floodplain with eroded soil to a depth of several meters (*7*). These events coincided with the beginning of a longer-term trend of increasing aridity and punctuated erosive landscape disruption, such as gully incision, soil erosion, and river course changes.

Nonetheless, this agriculturally based proto-urban society persisted in a gradually desertifying landscape through the use of suitable land management strategies: Its people captured water in cisterns, used trickle irrigation, exploited the floodplain margins for agricultural production, and eventually terraced hillsides during Moorish times (some 500 years ago). These soil conservation measures curtailed erosion, retained dwindling moisture levels, and—until very recently—made subsistence agriculture possible. For the past two decades, tourism-related development, water abstraction, and monoculture farming and field amalgamation have led to severe surface instability, dramatic gully incision, and soil and sediment erosion, denuding large areas to a desert-like state.

In highland Yemen, Wilkinson (*8*) observed the drying out of lakes by ~5000 B.C.E. and generally drier conditions from ~3000 B.C.E.; this coincided with settlement expansion into the highland hinterlands and concomitant soil erosion. Climate data from deep-sea cores suggests that rainfall was also changing from a moist, lengthy springtime rainy season to less frequent but more intense winter rainstorms. These factors combined to intensify soil erosion, flooding, and soil accumulation in low-lying areas downstream. Nonetheless, subsistence farming has remained sustainable in these hinterland valleys until today without the use of deep-well irrigation, through land use practices such as small embanked fields, shallow plowing, and crop rotation under the current lower-rainfall regime.

A scenario similar to that of hinterland Yemen had been envisaged for the highland Ethiopian landscape across the Red Sea at Aksum (*9*). But recent geoarchaeological studies, combined with intensive archaeological field surveys, have indicated that major disruption and erosion of this landscape probably did not occur until the past few hundred years, despite the longer-term trend of aridification and the intensive settlement and agricultural base associated with the Aksumite Kingdom from ~400 B.C.E. to 1200 C.E. (*9*).



Beyond data visualization. In a dynamic GIS-based simulation, archaeological and environmental data are combined to understand landscape change. For example, the prehistoric sites of the Wyke Down area of Cranborne Chase, Dorset (**bottom**) have been studied in this way. Pollen data provide information on arboreal cover for the same area in the later Neolithic (**middle**), showing that there was 64% open ground. GIS modeling provides information on the grazing intensity required to keep the landscape at this level of openness (**top**).

Computer modeling of past landscapes can enhance and alter our perception of dynamic people-landscape interactions in the archaeological record (*10–12*). For example, the universal soil loss equation (USLE) and geographic information system (GIS) modeling have been used to investigate how Roman agriculture may have affected erosion in the Troina Valley of north central Sicily (*1*). The results suggest that greater clearance for winter pasture land was the major driving force in intensifying soil erosion.

Another approach is to use dynamic spatial models commonly used in landscape ecology to test how landscapes have changed in the past. Samarasundera has used this approach to study the upper Allen Valley of Cranborne Chase in the chalklands of southern England (see the figure) (*2*). He used well-dated, repeated, and spatially related archaeological, paleosol, palynological, and mollusk data, as well as data on livestock grazing behavior and ecological succession scenarios, to develop a range of landscape use models for the Neolithic period (from ~9500 to 3500 years ago). He concluded that livestock grazing could have caused and maintained forest recession in the early Neolithic. This is a plausible alternative to theories of arable intensification for the extensive use and exploitation of the downlands in the late Neolithic and Early Bronze Ages, as suggested hitherto (*13*, *14*).

Barton *et al*. (*3*, *15*) have further applied and developed USLE and GIS modeling with their use of a geographic resource analysis and support system (GRASS) to model Neolithic subsistence land use practices in the Wadi Ziqlab drainage of northern Jordan. The authors used raster cell sets of topography, soils, vegetation, and regional climate data to investigate alternative scenarios of long-term landscape–land use dynamics. The study suggests two alternative scenarios of landscape development: disaggregation from village to small hamlet, and grazing dominating over cultivation.

The work (*3*, *15*) successfully builds on a recent legacy of applying GIS-based modeling to archaeological landscapes (*4*, *11*), but aims to take the process one step further to explore human decision-making. This approach will not only enable comparisons between long-term landscape dynamics and the archaeological record; it also provides the tools for further testing of human-environment interactions in different landscape settings and at different scales of human activity, from household to field to valley-wide.

Where comprehensive sets of well-dated and spatially related archaeological and paleoenvironmental data are available, the use of GIS-based modeling platforms is undoubtedly a productive way forward. Such paleoecological modeling can go beyond testing archaeological hypotheses that "play out" possible realities. Rather than merely providing simple data visualizations, it can combine different sets of data and allows the interrogation of many possible scenarios of change (*16*). Detailed understanding of long-term human impacts on landscapes is thus achievable, especially when coupled with precise climate data.

Furthermore, the simulations can link past, present, and future environmental data sets, allowing the prospect of assessing current and potential future human impacts on our environment. Perhaps this is an imperative given our current fragile and unpredictable times, but modeling is no absolute substitute for good paleoenvironmental data directly related to human activities in well-understood culturally shaped landscapes.

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