Introduction to Archaeology: Notes 5

Remote and subsurface sensing, GIS, and landscape archaeology

- Title slide: a "water witch" using a "dowsing rod" to find water in Merced.in 2008
  - this has actually been tested for archaeological use
  - but has found extremely little acceptance…
  - don't put it in a grant proposal or a test!

- **Remote sensing**
  - methods of "seeing" things from a distance, without contact
  - originally used for cameras and instruments borne by aircraft or satellites
    - such as satellite or aerial photos
    - often in specific wavelengths that are sensitive to certain kinds of features of interest, like healthy plants
    - some of these wavelengths are invisible, like infra-red light, so the "photos" are presented in "false color"
    - also magnetic data, soil humidity, thermal data, etc.
  - now sometimes also used for sensing things below the ground with an instrument on or above the ground
    - they are "remote" because they are below the surface
  - Kelly & Thomas say it must use "electromagnetic radiation", but it also includes other methods
    - especially electrical current
    - in geology and special archaeological cases, vibration (sound), etc.

- **Subsurface sensing** or **subsurface testing**
  - capturing information about what is below the ground's surface without digging it up
  - may be technically "remote" sensing, done from the air, or space
  - may involve contact with the ground surface or probes stuck into the ground
  - partial overlap with remote sensing

- Why do all this high-tech sensing?
  - saves money; is faster and more efficient
    - because excavation is very slow and expensive
    - remote sensing can cover a lot of area in little time
      - even if the equipment is expensive, it can be far cheaper than excavating a large area
    - can guide where to focus excavation efforts to answer specific questions, getting the most bang of information for the excavation buck
  - is non-destructive
    - excavation destroys the excavated area
    - no one can ever excavate the same spot again
    - tremendous responsibility to document the findings thoroughly, and interpret them correctly
    - so remote sensing allows us to answer questions while destroying much less of a site

    - leaving much more for future archaeologists to investigate to verify our claims, or to address other questions

- Satellite photos
  - visible light, or false color infrared, or others
  - tend to be small scale, covering a large area
  - good for seeing the regional setting of a site
  - what resources is a site located near?
  - what routes of travel could a site it be on?
  - is the location defensible, hidden, isolated, and other general setting questions
  - usually impossible to make out useful amounts of detail of buildings or other features within a site
  - lots of good imagery now available free via Google Earth
  - other satellite images, with better control of wavelengths and other technical details, can be purchased
  - or are available through some kinds of grants, like some National Science Foundation grants

- Most subsurface sensing methods depend on a difference between the cultural features that are being sought and the natural terrain
  - like finding rows of rocks in otherwise sandy soil
  - finding burned clay in contrast to unburned soils
  - finding voids (open spaces) versus solid soil
  - finding looser soil that fills trenches or pits, versus the more compact natural soil
  - in some environments, there just are no such useful contrasts
    - if your sensing method can tell rocks from fine-grained soil, but the soil of the region contains a lot of rocks, it will be hard to detect structures made of rocks
    - while you can sometimes guess that a given method is likely to work
      - as in the textbook's example of looking for burned wattle-and-daub buildings in the otherwise sandy soil of St. Catherine's Island
    - often you just have to try it and see what you find
      - note that one of the important finds on St. Catherine's Island using a magnetometer was the iron hoops of the lining of a well
      - which was not anything that they had expected

- Magnetometers (various different kinds)
  - measures slight increases and decreases in the strength of the Earth's magnetic field at a given spot
  - can detect
    - burned soil if it contains some iron minerals, especially clays
      - because when they are heated, the countless little magnetic domains in the minerals become free to change their orientation
      - they align with the earth's magnetic field
      - as the soil cools, they are frozen into that alignment

      - now, instead of lots of tiny magnets in different orientations that cancel each other out, the material's magnetic domains are all oriented in the same direction, creating a weak magnet
      - in their original orientation, this will slightly increase the magnetic field in the immediate vicinity
    - some kinds of rocks
      - like basalt, which cools from molten magma and adopts a weak magnetic field in much the same way as burned soil does
    - metals
      - even metals other than iron have weak magnetic properties
  - only works where human activity introduced something with different magnetic properties into the environment in patterns that can be distinguished from the natural landscape
  - example: Michael Coe using a magnetometer to find completely buried Olmec heads
    - and other carvings from basalt
    - which showed up well because the basalt was from the mountains some distance away, and was more magnetic than the limestone landscape of the Veracruz coast region
    - he just rode around on a horse with his magnetometer, and had his crew dig whenever he passed over a big jump in the local magnetic field
    - something like using a metal detector: just looking for rare anomalies
  - example of mapping with a magnetometer: Big Hidatsa Village
    - move the magnetometer back and forth along a grid, building up a map of readings across an area
    - burned soil of hearths are visible
    - surrounded by circular low-magnetism areas that proved to correspond to earth lodge floors
    - why were the floors less magnetic than the surrounding landscape?
      - there is probably a good explanation
    - but we don't even really need to know it
      - all we need is to see an apparently artificial pattern
      - dig enough of one to determine what it is
      - then assume that the other examples of that kind of pattern probably represent the same thing
    - so after excavating just part of one earth lodge, we can map, count, and otherwise analyze the whole pattern of earth lodges in as much area as we can cover with the magnetometer

- Soil resistivity surveying
  - measures how much the soil between two probes stuck into it resists the flow of electrical current
  - can detect
    - filled trenches and pits
      - because fill tends to be looser, holds more water
      - water with dissolved salts from the soil conducts electricity better than drier soil does
    - large rocks, or concentrations of rocks, as in wall foundations
      - because rocks conduct electricity less well than moist soil

    - metal, like pipes, which conducts electricity much better than soil does
  - can only work in soil moist enough to conduct some current
    - useless in very dry desert, or in dry, sandy soil that holds virtually no water
  - cannot work for trenches and pits in very wet conditions, because all of the soil is wet enough to conduct fairly well, whether or not it has been loosened by human activities
    - but stone walls could still be identified
  - older style: four probes stuck in the ground, wires to a control box
    - voltage applied to the outer probes
    - the inner ones measure the flow of current between them
    - wider (or sometimes deeper) spacing of the probes measures soil deeper down, but with lower resolution
    - "leapfrog" one probe to the end of the line, rotate a switch on the control box to connect the correct probes to voltage and measuring circuits, and take another measurement
    - cover the area in a grid pattern, building up a map of soil resistivity at set intervals over the whole area
  - newer style: a frame that holds the four probes.
    - stick it in the ground at a grid point, record the measurement, move to the next point
  - example results: Central Park, Grand Forks, North Dakota
    - again, first one notes apparently artificial patterns
    - in this case, some can be interpreted even without digging
    - for others, it might be necessary to excavate a few small areas to determine what a given kind of resistivity pattern represents
    - but then, the rest of those features can be mapped from the resistivity map without having to dig up the rest of the area.

- Ground penetrating radar (GPR)
  - what it measures is less well defined
  - "interfaces" between contrasting strata, rock features in soil, etc.
  - often just have to try it to see if it picks anything up
  - again, it works if human activity has created patterns that differ from the natural landscape
  - results can be maps similar to the previous two examples, and cross-sections along lines that the machine was dragged along
  - often harder to interpret than the previous two methods

- Kite aerial photography (KAP)
  - cheap, low-tech method of close-in remote sensing
  - increasingly common, but still a bit of a curiosity
  - does not see below the surface
  - but does give a view similar to satellite photography, but much closer and better resolution
  - useful for documenting architecture or other surface features
  - in low-angle (morning or evening) light, may show subtle features that are invisible from the surface
    - slight linear bumps that indicate buried or eroded walls
    - slight depressions that indicate the fill of pits that has settled slightly
  - low-elevation photos are also taken with balloons, remote-controlled airplanes, etc.

- uses a cheap digital camera, in my case a Canon that can be programmed to take photos at a given time interval automatically until the memory card fills up or the battery runs out

- **Geographic Information Systems (GIS)**
  - Essentially spatial databases
  - allow different datasets to be overlaid exactly
    - topography: hills, valleys, flats, cliffs, etc.
    - resources like arable land, pasture land, useful stone types, etc.
    - site locations, sizes, shapes
    - remote and subsurface sensing data
    - places were specific artifacts were found
  - this helps us see patterns that would be next to impossible to notice in data that was simply listed or tabulated
  - also can do spatial calculations using topography and other data
    - Least-cost paths: what is the easiest route between two points, considering both distance and slope?
    - Viewsheds: what areas are visible or hidden from this point?
    - Statistics: are sites significantly clustered, or randomly spaced?
    - and many others
  - example: overlaying precisely surveyed maps map by Bill Poe and Sue Hayes with KAP images
    - the maps benefit from precise measurements and close inspection of details on the ground
    - but the photos can show features that were invisible or missed from the ground
    - and also show features that were too vague to map on the ground, like rectangular flat areas defined only by changes in slope of the terrain
    - GIS allows them to be easily combined into an accurate, more complete final map of the site
  - example: plotting artifact distributions on a base map
    - easily shows patterns of where certain artifacts are concentrated or not
    - allows rapid checking for spatial patterns in any data recorded in the field

- **Landscape archaeology**
  - Study of ancient human modification of the environment
  - a broad-scale view, typically based on GIS maps, often with systematic site survey data and remote sensing data
  - examples
    - Chacoan roads
    - Andean terraced field systems and raised field systems
  - kinds of questions that can be asked and answered about, say, Andean terraced field systems:
    - when were they built?
      - answer by checking to see if they are spatially related to sites that were occupied in known periods
        - to know this, we would need to look at surface collections of ceramics, maybe the architecture on the sites, etc.

    - if all the fields are near sites occupied in Inka times, but sites from earlier periods are sometimes far from the terraced fields, that would suggest that the fields were built in Inka times
        - we have a supported hypothesis about the fields without even having to do surface collections, much less excavate anything, in those fields!
- were they part of a large system built by a state for regional needs, or just many independently-built family farms?
    - look at the total area of fields, estimate production
    - look at the size of the nearby sites, estimate population and their consumption needs
    - if there seems to be much more field area than the people would need, we can reasonably suggest that the fields were used to produce food for others, like tribute to the state for use by its army, etc.
- were they built by local people, or by immigrants to already-occupied areas?
    - are the fields near sites occupied by the indigenous people, or by immigrants who might have operated them like plantations?
- etc.