NEWS

Internet Software Programs Aid in Search for Amazonian Geoglyphs

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The Web-based Google Earth software program recently has incorporated high-resolution satellite imagery that facilitates the search for landscape expressions of past civilizations that we call geoglyphs. Since 2000, about 40 such geoglyphs have been observed in overflights above recently deforested pastures of southwestern Amazonia in eastern Acre State, Brazil [*Ranzi and Aguiar,* 2001; *Ranzi,* 2003; *Ranzi and Aguiar,* 2004]. These geoglyphs typically are circular or rectangular, on the scale of 100 meters or more, with bordering trenches 1–3 meters deep (Figure 1). Carbon-14 dating of charcoal associated with these geoglyphs indicates ages between 2500 and 1000 years B.P. [*Latini,* 1998; *Pärssinen et al.,* 2003].

The distribution of these geoglyphs has provoked questions such as, Were these constructions built in extensive savannas or in rain forests? What was the human population density that the region supported during the past few millennia? How much of the present-day forest structure and composition may have been influenced by human activity? Answers to these questions have important implications for understanding the ramifications of current climate change, the perspectives for long-term forest use, and the sustainable density of human populations in Amazonia [*Brown et al.,* 2006]. A more systematic analysis of geoglyph distribution would help frame the answers.

In eastern Acre and in the southern section of the Brazilian state of Amazonas, expanding deforestation has permitted airborne and satellite observations of local topography. While some geoglyphs were discovered during fieldwork in the late 1970s [*Dias Júnior and Carvalho,* 1988], most of the more recent discoveries have occurred by cursory observations from commercial airline flights and dedicated overflights in

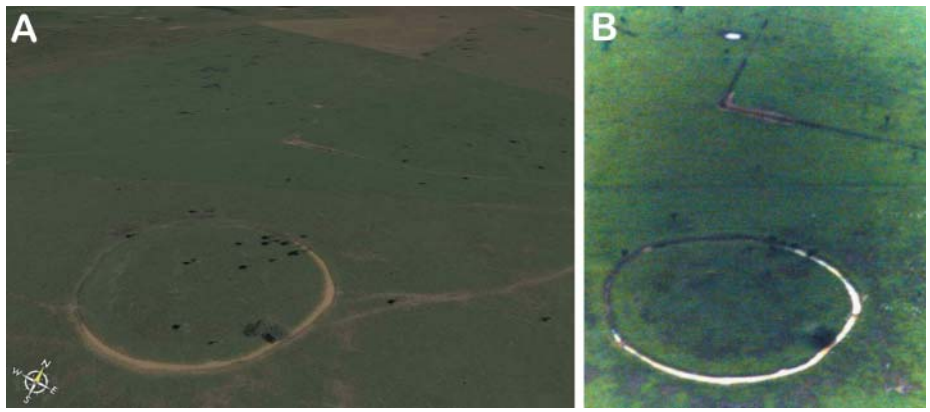

Fig. 1 (a) Geoglyph located in eastern Acre State, Brazil. Image acquired from Google, August 2006. Diameter of ring geoglyph is approximately 200 meters. Coordinates are 10°11'28"S, 67°43'19"W. DigitalGlobe catalog ID 1010010001E9BA06; acquisition date 16 May 2003. Google Earth imagery © Google Inc., Europa Technologies; © 2007 TerraMetrics, Inc., http://www.truearth.com. Used with permission. (b) Air photo of same geoglyph as in Figure 1, taken 8 June 2001. Photo by Edison Caetano.

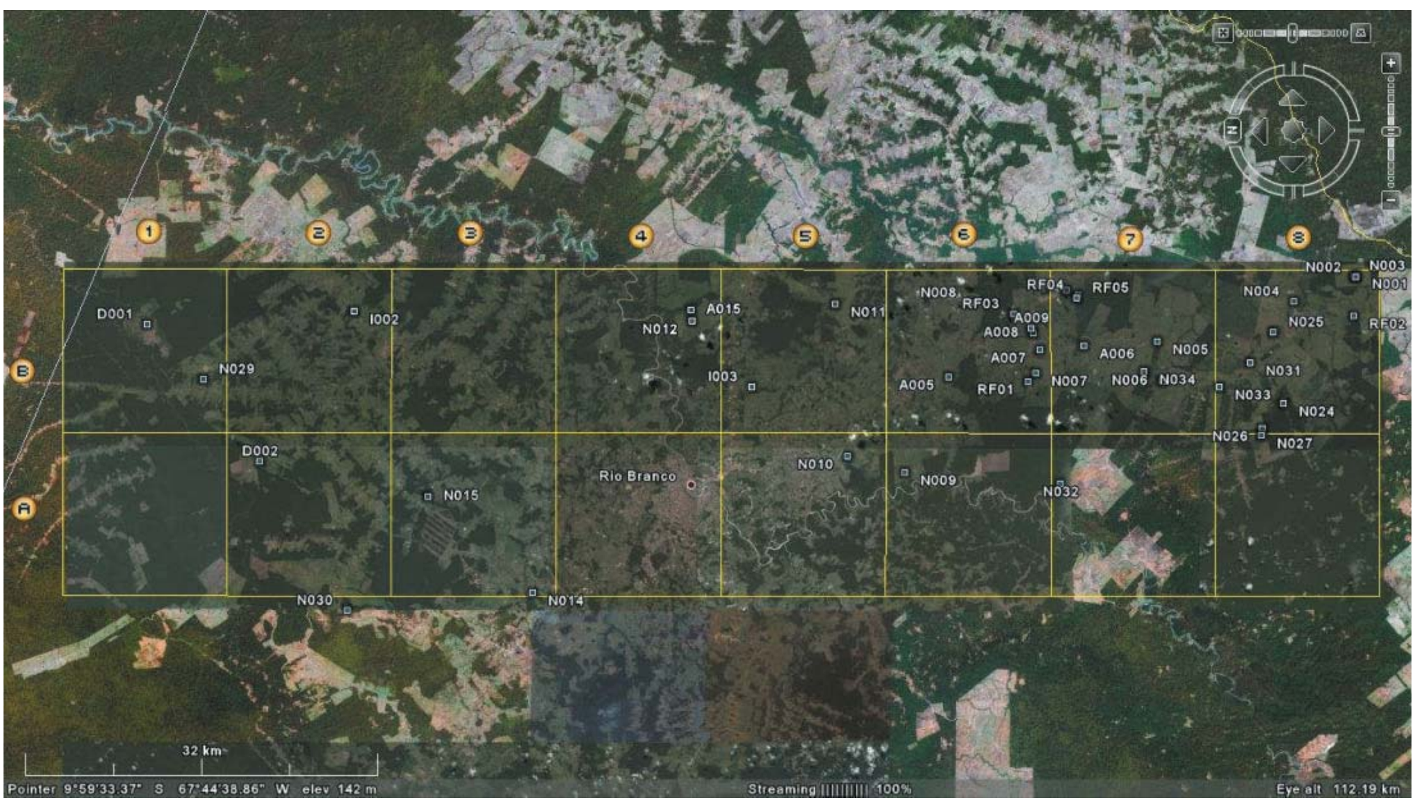

Fig. 2. A 120 × 30 kilometer grid with 225-square-kilometer cells overlain on a Google image acquired in August 2006. Note that the long axis is approximately north (left)/south (right). Points listed are possible geoglyphs. Google Earth imagery © Google Inc., Europa Technologies; © 2007 TerraMetrics, Inc., http://www.truearth.com. Used with permission.

small planes [*Ranzi,* 2003]. Until the past year, high-resolution Ikonos and QuickBird imagery was too expensive for local researchers to use in surveys for geoglyphs. The incorporation of such imagery by Google Earth for extensive stretches in Amazonia has permitted researchers to search for geoglyphs in eastern Acre.

Figure 2 shows how preliminary data analysis can be done with high-resolution satellite imagery to determine the areal density and distribution of geoglyphs. In this transect, 39 potential geoglyphs were observed in an examination of the imagery. Through fieldwork and overflights during the past three decades, only nine geoglyphs had been discovered in the area of the transect. In just a few hours of studying the Google imagery, the number of possible geoglyphs more than quadrupled.

Using the 225-square-kilometer cells as sampling units and normalizing for the area deforested (estimated by thirds), the average number of geoglyphs in the transect was determined to be 1.5 per 100 square kilometers with a range from 0 to 4.4 per 100 square kilometers. South and east of the Acre River, the average density of geoglyphs is 2.1 per 100 square kilometers, more than double the density of 0.8 per 100 square kilometers north and west of the Acre River. Assuming a range of 10–100 persons per geoglyph, the average 1.5 geoglyphs per 100 square kilometers would be equivalent to 0.15–1.5 persons per square kilometer; the latter figure is similar to the rural population density of Acre State in 2000.

The large number of potential geoglyphs permits spatial discrimination of their forms. In this transect, the Acre River serves as a divider between the two common forms of geoglyphs: circular and rectangular. Southeast of the river, 30 of the 32 geoglyphs are circular, while northwest of the river five of the seven geoglyphs are rectangular.

The incorporation of high-resolution imagery in Google Earth and other similar software has created a tool that is providing new perspectives on ancient land use in southwestern Amazonia. These new perspectives may help resolve the issue of how climate has changed in the region and whether this part of Amazonia is a "cultural artifact," in the words of Charles Mann, the author of the best-seller *1491: New Revelations of the Americas Before Columbus* [*Mann*, 2006].

For more information about Google Earth, visit the Web site http://earth.google.com.

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Analyzing Micromagnetic Properties With FORCIT Software

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A primary method of characterizing the magnetic properties of a sample is to measure its magnetization while gradually varying an applied ambient magnetic field between large positive values and large negative values. The change in magnetization with field can be used to map the magnetic hysteresis loop of the sample, which defines some of its bulk magnetic properties (Figure 1).

Each sample, however, is actually composed of a population of magnetic grains and domains, which may vary in their magnetic properties and which may interact with their neighbors. The micromagnetic properties of these populations, such as the distribution of micro-coercivities and the magnetic interactions or biases, can be mapped by probing the interior of a hysteresis loop with a series of partial hysteresis curves referred to as first-order reversal curves (FORCs) [*Mayergoyz*, 1986; *Pike et al.*, 1999] (Figures 1 and 2). These properties can then be used in various ways ranging from characterization of the magnetic composition, grain size, and concentration of samples to understanding the mechanisms of magnetic acquisition [e.g., *Pike et al.*, 1999, 2001; *Roberts et al.*, 2006; *Carvallo et al.*, 2006; *Muxworthy et al.*, 2005].

For example, we recently used FORC distributions to illustrate that coercivity distributions and magnetic interactions in some chondrules (millimeter-size spherules of rock) from chondritic meteorites appear to be ideal for recording the paleointensity of the magnetic field of the early solar system, whereas other chondrules have such strong interactions that it would be unlikely that they would give accurate paleointensity estimates [*Acton et al.*, 2007]. Knowledge of the paleointensity is important for understanding the origin of our solar system. The magnetic fields of proto-stars are thought to play a significant role in dissipating mass and angular momentum from accretionary disks prior to the formation of protoplanetary clumps. The magnetic field of our proto-Sun may even have been responsible for launching chondrules to planetary distances, where they were accreted into planetesimals and planets [*Shu et al.*, 1997]. Besides being used in planetary sciences, FORCs are being used increasingly in geological studies, such as those seeking to determine the origin of magnetic anomalies over ocean basins (Figure 2), and they are also becoming increasingly important in studies of magnetic recording media used in computer disks [e.g., *Cimpoesu et al.*, 2006; *Winklhofer and Zimanyi*, 2006].

Although the use of FORCs has grown rapidly since the late 1990s, analyzing the large amount of data commonly collected for a FORC measurement and producing plots of FORC distributions have remained time-consuming, difficult, and relatively expensive because existing FORC software has been tied to commercial graphical software packages.

To facilitate the use and interpretation of FORCs, we have written a software package called FORCIT. The software creates a number of PostScript plots that show the instrumental drift that occurred during the measurement, the micro-susceptibility, the trajectories of FORC paths, and the FORC distribution in several two- and three-dimensional perspectives as well as inside the major hysteresis loop, and a profile of the quasi-reversible FORC distribution (Figure 2). The software is a combination of Unix shell scripts, Fortran 77, and Generic