Reports

Beans for Valdivia

Abstract. *Carbonized remains of* Canavalia *beans were recovered from archaeological deposits excavated at Real Alto (OGCh-12), southwestern Ecuador. The identification, context and dating of the earliest beans from Real Alto demonstrate their use from the beginning of Valdivia (about 3300 B.C.) and the Early Formative in coastal Ecuador.*

Research aimed at delineating the economic base of Valdivia culture is producing a body of data on the presence of agriculture. Evidence that corn (*Zea mays*), cotton (*Gossypium*), coca (*Erythroxylon coca*) and achira (*Canna*) were being cultivated has been presented (*1–4*). Excavations in 1977 at Real Alto (OGCh-12), Chanduy Valley, Ecuador, yielded evidence that *Canavalia* beans, probably domesticated, were cultivated from the onset of the Valdivia occupation (*4, 5*).

The botanical samples from the 1977 excavations included three carbonized fragments of sufficient size that gross morphology could be used to make an identification at the family level. An identification as legume seeds of the Papilionoideae type was suggested by the presence of two large cotyledons with curved exterior surfaces and flat, slightly concave interior surfaces; the kidney-bean shape in overall outline; the presence of a faint hilum (attachment scar) on the long side of the cotyledon; and a lack of characteristics associated with the other subfamilies of the Leguminosae. In addition, the dense character of the carbonized cotyledons made them distinct from the more porous carbonized wood and tuberous root fragments encountered in other Real Alto samples.

CS 91 consists of three small fragments of dense tissue with curved, smooth exterior surfaces; they are of insufficient size to orient for measurement. CS 94 is an almost complete cotyledon with partial attachment of the second cotyledon; it has a kidney-bean shape, with length 11.45 mm, width 4.65 mm, and thickness (one cotyledon) 3.00 mm. CS 95 is an almost complete seed with both cotyledons present and attached; the dimensions are length 13.30 mm, width 9.50 mm, and thickness (two cotyledons) 7.65 mm. A comparison to modern wild Leguminosae seeds collected from the coastal plain of southwestern Ecuador and to published measurements of cultivated *Phaseolus vulgaris* (common bean) and *P. lunatus* (lima bean) revealed that the archaeological specimens were larger than the wild species, but did not correspond in size and proportion to either the wild or cultivated common or lima bean (*6*).

Electron microscopy of the cell wall anatomy of the cotyledons enabled the identification of all three samples as *Canavalia* sp. (Fig. 1). Because the specimens are carbonized, the species identification is not secure. The width of the hilum in CS 95 (about 3 mm) is within the range for domesticates. Conservatively, the seeds may be of the wild coastally distributed *Canavalia maritima* but are probably of the domesticate *C. plagiosperma*.

The carbon samples from Real Alto are three of seven found in situ in the refuse zone of a Valdivia I household cluster. The refuse zone comprises a concentration, up to 10 cm thick, of dense shell surrounding a remnant structure (structure 2-77) identified by an elliptical pattern of 30 post molds (450 by 320 cm). The mangrove-specific *Anadara tuberculosa* and *Cerithidea pulchra* are the most conspicuous elements of the refuse zone, which apparently accumulated with the disposal of unused food and other refuse around the perimeter. Valdivia I (about 3300 to 2700 B.C.) ceramic shards were found in definite association with this refuse zone and the house floor (*5*).

The context of the carbonized seeds is certain, since they were veritably cemented in place. The calcium carbonate from the shell probably facilitated preservation. The seeds are not intrusive, because several of them were found inside bivalve halves in undisturbed deposits surrounding structure 2-77.

Eleven radiocarbon determinations are available for Real Alto. Two of these, from charcoal samples, date the strata related to structure 2-77 and the carbonized seeds: 5495 ± 200 years (GX-5267) and 4900 ± 170 years (GX-5268) before the present. The first comes from the

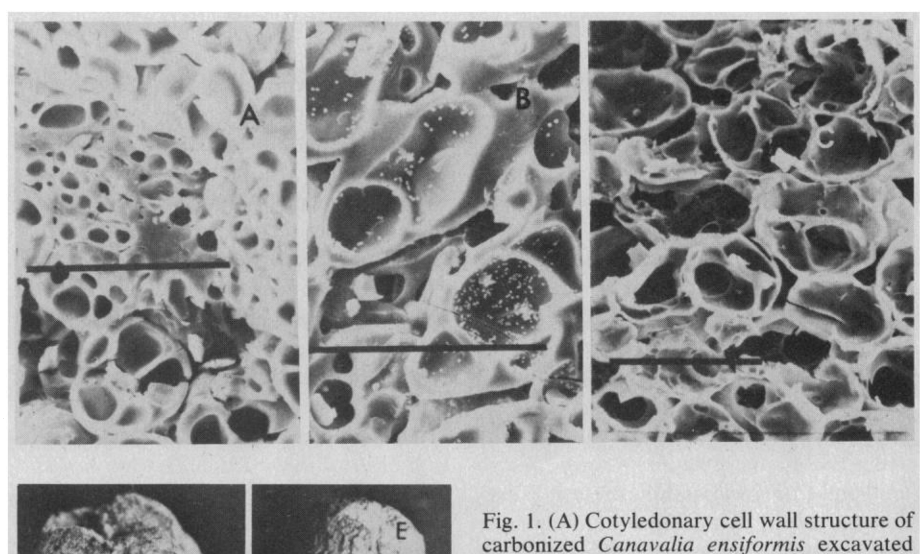

Fig. 1. (A) Cotyledonary cell wall structure of carbonized *Canavalia ensiformis* excavated from a site in the Peten; (B) *Canavalia* sp., CS 94, Real Alto; (C) *Phaseolus vulgaris* from Point of Pines, Arizona; (D and E) hilum region of CS 95, Real Alto. (A), (B), and (C) are scanning electron micrographs, carbon-gold coated; scale bars, 100 μm. (D) and (E) are light photomicrographs; scale bars, 0.5 mm.

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refuse zone adjacent to structure 2-77. The second dates the upper surface of this zone and several cairns. The other nine dates are consonant, given statistical probability. The earliest date may be too early for Valdivia I, but the second date is in accord with those from another early Valdivia site, Loma Alta. A period around 3300 B.C. seems plausible for the appearance of Valdivia on the Ecuadorian Pacific coast.

After the identification of the original three carbon samples, the Real Alto carbonized materials were reexamined for fragments of dense carbon similar to the cotyledon fragments in the three original samples. Another sample, CS 93, also excavated in 1977, contained five such fragments. Sixteen other fragments were found in samples from the Valdivia I, Valdivia III, Valdivia IV/V, and Valdivia VI phases and nine fragments from as yet undated Valdivia features (*4*). This suggests that *Canavalia* was used during Valdivia I times and throughout the occupation of Real Alto. The possibility that *Canavalia plagiosperma* was present at Real Alto as a domesticate and was used as a food resource by the Valdivians is thus supported.

Other findings suggestive of the presence of agriculture during the Early Formative of Ecuador include phytoliths (silica bodies deposited in the leaves of certain plant families) identifiable as a maize type, which occur as early as Valdivia I at Real Alto and continue throughout the later Valdivia and Machalilla occupation (*3, 4*). Beginning in Valdivia III, phytoliths identified as Cannaceae, the family of the edible cultivated achira *Canna edulis*, also occur. Since there are no native Cannaceae on the coastal plain of southwestern Ecuador, the introduction of cultivated *Canna* is a possibility.

The prehistoric occurrence of the South American domesticated *Canavalia plagiosperma* is known for coastal Peru beginning with the Late Preceramic (about 2500 to 1800 B.C.). *Canavalia* was recovered by Bird at Huaca Prieta in coastal Peru (*7*). Connections between Huaca Prieta and Valdivia have been suggested (*1*). The presence of the wild and possibly ancestral forms of *C. maritima* and *C. brasiliensis* in western Ecuador and of *C. maritima* extending into extreme northern Peru (*8*) indicates that this region was probably a site of early *Canavalia* domestication. The Real Alto data give chronological priority to a northern Ecuadorian origin.

One additional point is significant. *Canavalia* species are confined to humid areas. Irrigation in some form is necessary for growing the domesticated species in areas with short rainy seasons. Since the southwesternmost part of Ecuador is an area of marginal rainfall with a short rainy season, the presence of prehistoric *Canavalia* at Real Alto indicates a wetter area of origin for Valdivia, possibly the Colonche hills and the Guayas Basin of Ecuador.

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Microparticle Concentration Variations Linked with Climatic Change: Evidence from Polar Ice Cores

Abstract. *The microparticle concentrations in three deep ice cores reveal a substantial increase in the concentration of insoluble particles in the global atmosphere during the latter part of the last major glaciation. The ratio of the average particle concentration in the late glacial strata to that in the Holocene strata is 6/1 for the core from Dome C, Antarctica, 3/1 for the core from Byrd Station, Antarctica, and 12/1 for the core from Camp Century, Greenland. Whether this temporal correlation between increased atmospheric particle load and the lower surface temperatures is directly causal is unknown; however, the variations in these two parameters must be satisfactorily resolved in any successful hypothesis that addresses the causes of climatic change.*

The dry snow facies of the continental ice sheets and ice caps contain particulate material and isotopic species that provide information about the physical properties of the atmosphere at the time of precipitation formation and deposition. These data must be interpreted cautiously, as the complex relationship between particles (and gases) in the atmosphere and those in the associated precipitation is poorly understood (*1*). Nevertheless, a substantial increase in the quantity of material suspended in the global atmosphere should be recorded within the particle stratigraphy of the polar ice sheets.

The concentration and size distribution of insoluble particles within firn and ice cores are determined by the Coulter technique conducted within a class 100 clean room (*2*). Thus far, three ice cores encompassing at least the end of the last major glaciation (correlative with the Late Wisconsin or Würm stage) and the postglacial (Holocene) strata have been analyzed for microparticle concentration and the $^{18}O/^{16}O$ ratio ($\delta^{18}O$), a paleoclimatic indicator revealing the glacial-postglacial transition. These three cores are those from Byrd Station, Antarctica (2164 m) (*3, 4*); from Camp Century, Greenland (1387 m) (*5, 6*); and from Dome C, Antarctica (905 m) (*7–9*).

The examination of individual particles by light microscopy and scanning electron microscopy coupled with elemental analysis by an x-ray energy-dispersive system (XEDS) is a routine part of the microparticle analysis procedure (*10*). The Camp Century core particles are composed primarily of clay minerals (*5, 11*), whereas both clay fragments and volcanic glasses were found in the Byrd core (*2*). These volcanic glasses are much more abundant in the late glacial sections of the Byrd core than in the overlying Holocene sections. The XEDS analyses are conducted only for particles with diameters greater than 5 μm, as the analysis of smaller particles is unreliable.

The particles in the Dome C core fall into two distinct classes according to size. The smaller particles (with diameters ≤ 2 μm) are more abundant by three or more orders of magnitude. The less abundant, larger particles (diameters be-