lattice will be modified by the presence of heavy atoms, since the phase shift on scattering, from a heavy atom, is different from that for a light atom (*6*).

Some variation in fringe intensity is seen for both the normal and the barium-treated samples; generally every fifth or tenth fringe appears darker (Fig. 1A, *dp*), and in some areas the extinction contours follow this variation, in a stepwise grouping; the effect is more obvious with the barium-treated sample. These larger groupings may represent screw dislocations (*7*) or growth steps. Dislocations due to stacking faults were not observed except as indicated in Fig. 1A (*sf*).

All the micrographs were selected from a through-focus series of six to eight exposures, each made with a focal change of 0.05 μ. When a pair of negatives separated by a focal change of 0.2 to 0.3 μ is examined in a stereoscopic viewer, one has a three-dimensional view of Bragg diffraction effects within the muscovite (*8*); the grouping of lattice planes previously mentioned is more apparent, and there appears to be some vertical shifting of groups. The extinction contours are not the effects of simple bending but are distributed through the depth of the section.

Lower magnification (Fig. 2A) shows the frayed edges of some of the particles. Fraying results not only from breakage of the larger crystals but also from dissolution of the crystal edges by the autoclave treatments. Individual layers, although separated at the ends, tend to cling together; this factor probably results from drying during the embedment procedure.

The edges of the naturally weathered clay-size muscovite from the Nason soil (Fig. 2B) are not nearly as frayed as flakes weathered in the autoclave. Groups of 5 to 20 10-Å layers protrude from the edge; these stacks appear to be related to planes extending into the particle.

Clay-size mica flakes apparently can be sectioned with little deformation of the lamellae by stress; an observation with crysotile fibers was similar (*3*). Our attempts to cut 20- to 5-μ particles failed, however. Embedment and exposure to high vacuum alters the layer spacings and edges of weathered mica flakes. Nevertheless, significant morphological features of individual molecular sheets can be distinguished by ultramicrotomy and electron microscopy.

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Paleo-Indian Remains from Laguna de Tagua Tagua, Central Chile

Abstract. *Bone and stone tools associated with extinct fauna (horse and mastodon) place man's occupation in central Chile at 11,380 ± 320 years ago.*

The area known as Laguna de Tagua Tagua, in the valley of the Rio Cachapoal (Province of O'Higgins), has been renowned for more than a century as a locale containing remains of Pleistocene fauna. In 1967, a group of Chilean scientists (*1*) organized a program for its systematic excavation. During the 1st week of work, a stone flake was encountered in association with the lower mandible of a mastodon, with the result that the primary focus of the investigation was transferred from paleontology to archeology.

Laguna de Tagua Tagua occupies a basin surrounded by the Cordillera de la Costa which rises to an elevation of 1000 m. The only natural outlet is the corridor of Cochipuy, a relatively narrow pass opening to the northeast. The area selected for excavation is an approach to the lake that is surrounded by low hills, making it a favorable region for hunting of animals as they came to drink. The region was seasonally if not permanently inundated, and probably was swampy (this will be clarified after completion of sediment analyses).

During the first 4 months of fieldwork, about 120 m^2 were excavated to a depth of 2.3 to 2.4 m. Artifacts were encountered in two levels. The most recent, at a depth of 1 m below the surface, corresponds to a group of hunters and gatherers or incipient agriculturalists. Characteristic artifacts are grinding implements and projectile points of types known from the adjacent coast. Fauna consists of modern species. This horizon is estimated to date about 3000 years ago.

At a depth of 2.40 m, chipped tools are associated with remains of extinct fauna. Bones of horse (*Hippidion*?) and mastodon (probably a new form), deer, and canid occur in a fragmentary and dispersed condition that reflects human activity; there is no evidence of natural disturbance to account for dismembering of skeletons. Much more abundant are bones of birds, frogs, fish, and rodents. Horse skeletal parts represent a single individual and include caudal vertebrae, ribs, and portions of the extremities. An astragalus and calcaneum show prominent cuts by a tool, probably produced during severing of a ligament. These cut marks continue across both bones. Many bones have been splintered by blows, and the absence of anatomical arrangement also implies butchering. The mastodon remains, also scattered and incomplete, include the basal portion of a skull lacking incisors, a mandible, two vertebrae, portions of femur, tibia and fibula, scapula, and both halves of the pelvis (which were found 1.5 m apart with the basal portion of the skull between them).

Fifty artifacts were encountered during the first 4 months of excavation. They not only belong to the same stratigraphic level as the fauna, but frequently are found as close as 2 to 5 cm from the bones. Most abundant are flakes, some of lamellar type. Some constitute chipping residue, whereas others are artifacts (Fig. 1, a–d). The artifacts include flake scrapers, one of which resembles a type described from the Domebo site in New Mexico. One flake is retouched at the distal ends, another on the proximal end and sides. Material is principally chalcedony and basalt. Obsidian flakes and an obsidian knife also occur. A prepared platform

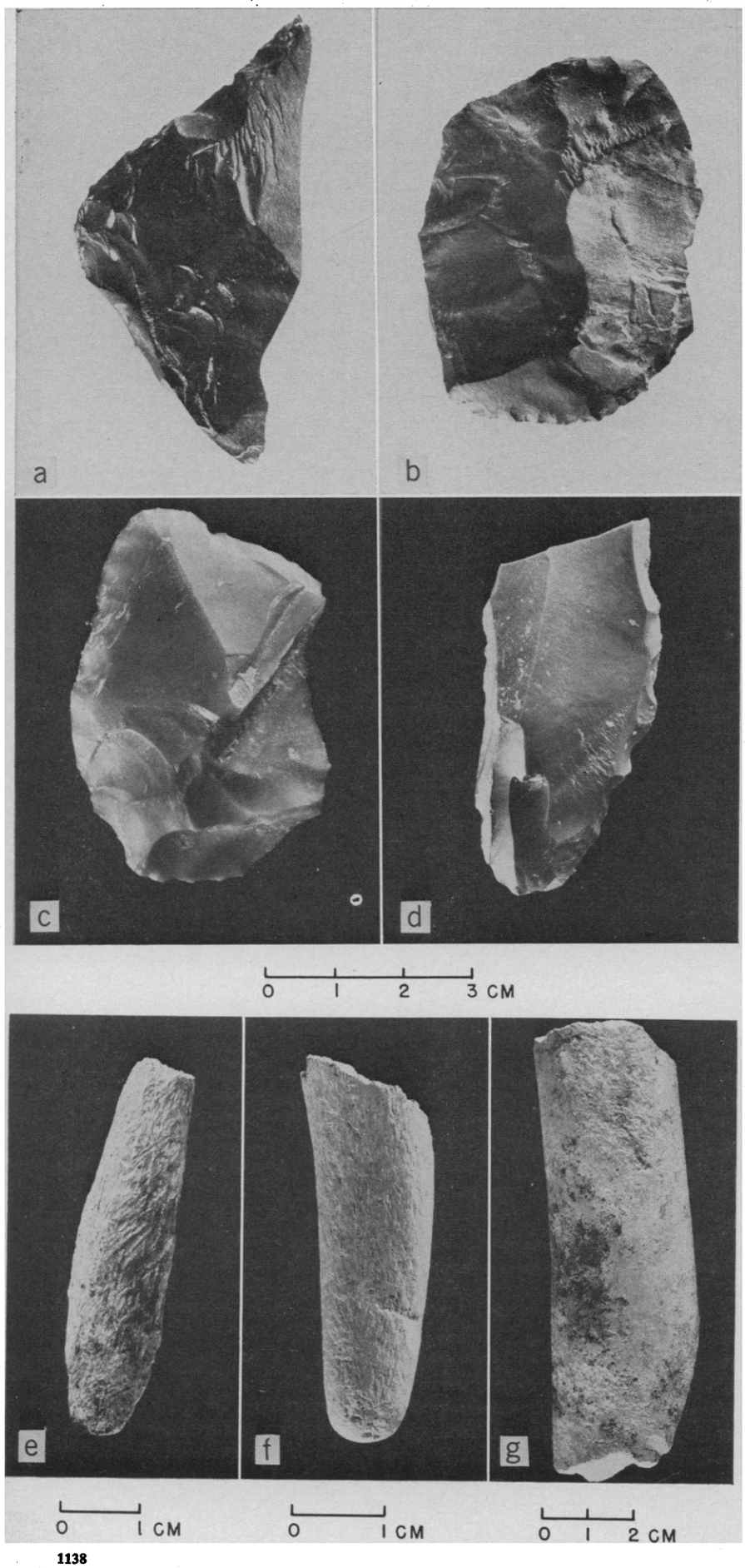

Fig. 1. Stone and bone artifacts associated with extinct fauna at Laguna de Tagua Tagua. (a–d) Flakes retouched on one or more edges; (e) worked bone; (f) pointed bone flaker; (g) bone flaker of the Quina type.

was used to strike flakes. Three crude granite artifacts were probably used to crack bones.

Of great interest are a number of implements fashioned of horse bone (Fig. 1, e–g). These include two types of flakers, one pointed like those found in early North American sites and the other of the Quina type found in European middle and upper Paleolithic sites. Some exhibit high-use polish. Several fragments of mastodon incisors have been procured by percussion, and one appears to show secondary shaping.

Association in a ½-m square of a chalcedony scraper, a flaker, and chips removed from the scraper during retouch of the working edge, provides clear evidence that the hunters sharpened their tools as required during the butchering process.

Flecks of carbon are distributed in the soil throughout the lower level, particularly in the vicinity of the fossil bones. They may have originated from a campfire, in view of traces of burning evident on one mastodon bone. Alternatively, they may have been deposited from fires set by the hunters to assist in capture of the game, or by natural causes. In any case, there is no doubt of the contemporaneity of the charcoal, the fossils, and the artifacts.

A charcoal sample and a fragment of mastodon bone were submitted for carbon-14 dating to Geochron Laboratories, Inc. (*2*). The bone's age could not be determined. The charcoal sample, however, was dated at 11,380 ± 320 (GX-1205) years ago—the earliest date yet obtained for human occupation in Chile.

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References and Notes

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