Because the density of photons is so low in interstellar space the atoms and molecules that exist there are almost universally in their absolute lowest energy state. The resonance lines of abundant atoms occur mostly in the vacuum ultraviolet whereas the radiation from molecular species is rotational transitions that are detected at millimeter and centimeter radio wavelengths. The launching of the Orbiting Astronomical Observatory series of satellites, culminating in the launching of the Copernicus satellite, has enormously expanded our ability to detect and recognize the ionization state of the abundant elements in the interstellar medium, and advances in millimeter-wave and radio astronomy have now led to a list of over 40 distinct molecules detected in the interstellar medium.

At the 16th General Assembly of the International Astronomical Union, the Commission on Interstellar Matter met jointly with commissions on space research, radio astronomy, galactic structure, and galaxies to present a series of 24 invited review papers that discussed recent developments in the understanding of the interstellar medium.

It was originally intended that the papers would be presented only orally, but their reception inspired van Woerden, the president of the Commission on Interstellar Matter, to publish them. A number of the papers are not as thorough as they might have been if they had been prepared for a publication aimed at a more general audience. Complete coverage of the field was sacrificed in order to cover some of the newer developments in depth. Notably missing are reviews of the wealth of material Copernicus has accumulated on the physical conditions in neutral hydrogen clouds and of the radio observations of high-galactic-latitude neutral hydrogen clouds and a definitive review of the status of the classical observations of interstellar absorption features in the visual region of the spectrum.

With the exception of these gaps the entire subject is covered, and the numerous references would be useful to anyone interested in extending his or her knowledge of specific topics. Particularly noteworthy are the papers on the interstellar coronal gas by Jenkins, Cox, McKee, and McCray, the paper on compact HII regions by Shaver, the papers by Dalgarno, Zuckerman, and Watson on molecular clouds, and the paper on isotopic abundances by Townes. The papers on the distribution of gas clouds in our galaxy by Hart and Burton and Gordon and the work on interstellar matter in external galaxies reported by Webster, Peimbert, and van Woerden are excellent summaries of the state of the art. Our current understanding of the important atomic and molecular processes in the interstellar medium, the interactions of the dilute, hot, gas phase with dense, cool clouds, and the history and distribution of gas in spiral galaxies is well documented by this collection.

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Early Irrigation Agriculture

Studies in the Archeological History of the Deh Luran Plain. The Excavation of Chagha Sefid. FRANK HOLE. With contributions by M. J. Kirkby and Colin Renfrew. University of Michigan Museum of Anthropology, Ann Arbor, 1977. xiv, 370 pp., illus. Paper, $10. Memoirs of the Museum of Anthropology, University of Michigan, No. 9.

Early southern Mesopotamian civilization was generated and maintained by a mode of production based upon the surplus yields of irrigation agriculture. Six-row hulled barley was the primary crop (at the end of the third millennium as much as 80 percent of temple-owned fields were under barley cultivation), and productivity was phenomenal: some mid-third-millennium texts indicate a 76-fold yield, and those of the late third millennium suggest still impressive 20-fold averages. Peasant agriculture in southern Iraq today, using basin-flow irrigation, rarely exceeds a 10-fold yield for a modern barley (*1*). When and why irrigation agriculture was first used in southern Mesopotamia is not known.

Until six years ago, the earliest known settlements in southern Iraq were those of the village- and town-based Ubaid ceramic tradition, beginning in the late sixth millennium and continuing, with no evidence for exogenous cultural change, into the period of city-states characterized by the Uruk ceramic tradition (around 3700 to 3200 B.C.). Under modern climatic conditions dry farming is not possible in southern Iraq; hence the early Ubaid settlers were assumed to have practiced simple gravity-flow basin irrigation, locating their villages along easily broken river levees. The origins of the Ubaid ceramic tradition were not known; no sites in southern Iraq provided a transition from the earlier Samarran sites distributed in the area to the northeast.

In the Susiana plain of southwestern Iran, a ceramic tradition parallel to the Ubaid of southern Iraq has been the subject of more extensive investigation; but the origin of the Susiana cultures has also been uncertain. Today dry farming is possible on the Susiana plain; only in the middle of the Susiana ceramic sequence did settlements align themselves in ways that indicate the practice of irrigation agriculture.

The Deh Luran plain lies northwest of the Susiana plain in the Zagros piedmont steppe. In 1963, Frank Hole, Kent Flannery, and James Neely excavated a succession of sedentary village occupations in Deh Luran which began around 7000 B.C. and continued into a sequence of cultures with ceramics similar to those of the Susiana plain (*2*). The earliest Susiana-related phase of occupation, the Sabz phase, provided evidence for irrigation agriculture, but the immediate antecedents of this phase were not present in the excavated sequence. The earliest Ubaid cultures in southern Iraq and the earliest Susiana cultures in southwestern Iran both seemed to be irrigation-based, but their origins remained obscure.

By 1967 evidence was accumulating for an irrigation-based culture, with ceramics apparently ancestral to those of the Sabz phase in Deh Luran, at the site of Choga Mami, 150 kilometers to the northwest in a drier Zagros piedmont zone. Hence the 1969 report of the Deh Luran excavations suggested that the Sabz phase represented the intrusion of an irrigation-farming culture into the Deh Luran plain. In 1968–69 Frank Hole excavated a sample of the site of Chagha Sefid in Deh Luran to document the cultures that immediately preceded the Sabz phase and to test the hypothesis of an intrusion from the area of Choga Mami.

The present monograph presents the results of those excavations, along with a detailed set of arguments for the hypothesis that irrigation agriculture was introduced by a migration from the Choga Mami area. This volume and Hole's earlier Deh Luran excavation report are unique in Near Eastern archeology: they are the only fully documented final reports of prehistoric Near Eastern excavations to appear since the Second World War. Hole's problem-oriented and interdisciplinary research continues to provide a foundation and a reference point for much of the prehistoric archeology conducted in Iran and Iraq. The Chagha Sefid report contains detailed and quantified descriptions of the architectural remains and the ceramic and lithic assemblages recovered from Hole's excavations, as well as a chapter that treats the relative and absolute chronology of the new occupation phases for

Chagha Sefid. Two important appendixes supplement the excavation data: Michael Kirkby's geomorphological analysis of land and water resources in Deh Luran and Colin Renfrew's analysis of the Chagha Sefid obsidian artifacts and late prehistoric obsidian trade in the region. Accounts of the retrieved faunal and botanical remains, entrusted to others for analysis, remain to be published.

Hole's new data reveal a set of marked changes in material culture for the pre-Sabz phase, labeled the "Choga Mami Transitional" after the occupation at Choga Mami with a similar ceramic assemblage. Do these changes signify the intrusion of irrigation-practicing peoples from the Choga Mami area into the Deh Luran plain? Choga Mami Transitional ceramics are now known from recent excavations on the Susiana plain and from new surface collections in southern Iraq. Does this distribution indicate that the early Susiana and Ubaid cultures are similarly derived from the irrigation culture of the Choga Mami area?

Too little has been published from Choga Mami and the Susiana plain and too little research has been conducted in southern Iraq to permit definitive answers to these questions. Hole extracts enough from the available data, however, to present a strong argument for a migration from the Choga Mami area into the Deh Luran plain. He suggests that the population growth encouraged by yields from irrigation agriculture in the original areas of Choga Mami Transitional settlement may explain this migration. Some may bridle at the association of "pots and peoples," but the association is more convincing when it is tied to changes in subsistence technology and population sizes in different ecological settings.

Hypotheses aside, the meaning of some fundamental data for early irrigation farming in southern Iraq and southwestern Iran remains to be clarified. Here it may be useful to note that irrigation agriculture in Deh Luran during the Sabz phase is still not a certainty. Pending the analysis of the botanical remains for the Choga Mami Transitional phase at Chagha Sefid, the evidence for Sabz-phase irrigation consists of two Sabz-phase linseed lengths, which Hans Helbaek argues could have been achieved only by irrigation agriculture (*3*). Although linseeds were reported for subsequent phases, only two carbonized specimens from the Mehmeh phase were measured. These samples, presumably also the products of irrigation agriculture, do not, when their lengths are "corrected" by van Zeist's shrinkage factor, reach the lengths of the supposedly "irrigated" Sabz-phase specimens. Precisely the same situation obtains with the few samples from Choga Mami. With prehistoric linseed lengths now more fully documented from a variety of ecological contexts, the data from the Sabz phase need reevaluation.

Linseed lengths might not permit discrimination between canal irrigation, basin-flow irrigation, and the products of a high water table, regardless of annual precipitation. Kirkby's geomorphological appendix, which reconstructs the environmental history of the Deh Luran plain, concludes that "reliance on a high water table, rather than . . . specific water control techniques" could account for the Sabz-phase crops. A similar interpretation could be attached to the pollen data retrieved from the Deh Luran sites (*4*).

Prehistoric agriculture in Deh Luran has been understood against the climatic background inferred from the analyses of pollen cores retrieved from the western Zagros. Yet no modern analogue of the cores' zone B vegetation (around 8000 to 4000 B.C.) is certain, and these cores have been taken to suggest both climatic conditions warmer and drier than those that prevail today and conditions close to the modern ones (*5*). New data, publicized after this volume was in press, suggest yet another climatic background. Sediment cores from the Persian Gulf show alterations in the quantity and quality of river-borne terrigenous sediments from the Zagros drainages and suggest that increased precipitation facilitated changes in settlement and subsistence in this period. A relatively sudden increase in the Zagros drainage discharge began about 5500 B.C. and continued to about 3000 B.C. During this peri d annual precipitation may have been 30 to 40 percent greater than today in the Zagros, and two to four times greater in the Mesopotamian lowlands (*6*). The onset of these conditions is roughly contemporaneous with both the earliest documented settlements of southern Iraq and the movement of Choga Mami Transitional ceramics to the Deh Luran and Susiana plains. Irrigation agriculture may not have been necessary in these regions, and in the absence of certain data its origins there still elude us. In the meantime, Frank Hole's research and publications continually redefine long-standing archeological problems.

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