the assumptions made in doing the calculations may not be valid, and the bias may result in apparent supersaturation results. The value of pK' for fluorapatite [$Ca_{10}(PO_4)_6F_2$, which is not shown] is 10^5 greater than the corresponding pK for all data; yet fluorapatite is not encountered in recent or ancient sediments. $Ca_2 \cdot HPO_4 \cdot CO_3^0$ and $Ca_2 \cdot PO_4 \cdot CO_3^-$ account for a great deal of the dissolved phosphate in sea water. The lack of consideration of these two ligands would increase pK' for the apatites by approximately 10^{10} (*6*). Since CO_2 appears in amounts varying up to 4 percent in CO_2-F-apatite (*7*), the stoichiometry and solubility constant used here are probably not representative of the total temperature range.

Sea water is saturated and unsaturated with respect to calcite and aragonite, as shown by the fields marked by the two solid lines in Fig. 1*C*. On the average, sea water 14°C or warmer appears to be saturated with calcite, and sea water 20°C or warmer is saturated with aragonite. These boundary temperatures probably represent minimum average temperature limits for obviously precipitating carbonate environments. It is interesting to note that the 20°C limit for aragonite corresponds to the minimum average surface water temperature associated with 30° north and south latitude limits of carbonate formation in the present oceans (*8*).

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Prehistoric Archeological Surveys and Excavations in Afghanistan: 1959–1960 and 1961–1963

Abstract. *Afghanistan has long been considered an important transmitter of culture in the historic periods. Buddhism, for example, reached the Far East from Gandhara (the classical name for southern Afghanistan and parts of northwestern West Pakistan). Recent research indicates that the foothills of northern Afghanistan may have been one of the early centers of incipient agriculture, transitional between the food gathering of the Paleolithic and the food production of the Neolithic. In addition, Upper and possibly Middle ("Mousterian") Paleolithic industries have been identified.*

In many archeological studies in the Near and Middle East since World War II, attempts have been made to locate and define the zones of the development of agriculture and the domestication of animals, the two important processes by which man learned to control his food supply (*1*). Earlier botanical studies indicated the possibility that the highlands of Afghanistan might also be an early center for the domestication of the wheat-barley complex of the Old World (*2*). Beginning in 1949, a series of expeditions to the Afghan-Pakistani area were organized for the purpose of investigating the prehistory of the region. Several monographs have been published on the findings of the first two (1949, 1950–51) expeditions (*3*).

In this report I describe tentatively some of the results of work at Darra Dadil-Darra Chakhmakh, Qala Shaharak, and Ghar-i-Mar (Snake Cave).

I conducted an extensive survey of northern Afghanistan during November and December 1959, and recorded over 100 caves and 150 mounds of archeological interest. Surface collections on many of the mounds yielded types of pottery which might be prehistoric (*4*). Also, the periglacial terraces of the Darra Dadil and Darra Chakhmakh valley (south of Mazar-i-Sharif near the town of Aq Kupruk, 36°05′N, 66°51′E), now completely dried-up stream beds, yielded several hundred flint cores and flake tools (primarily scraper types) of possible "Mousterian" affinities (*5*).

In October 1961, Klaus Fischer and I dug a test pit in a mound near Qala Shaharak (34°07′N, 54°25′E) in the western Hindu Kush mountains about 260 km east of Herat (34°20′N, 62°12′E). We collected painted pottery with possible prehistoric affinities from 30 separate mounds in the valley of Shaharak. No historic glazed pottery appeared in the test pit, but the ages of the lower and upper levels, estimated by radiocarbon dating, indicated that pottery samples were 1085 ± 120 years (Hv 206) and 720 ± 110 years (Hv 205) old, respectively (*6*). The range, therefore, extends from about A.D. 900 to 1200, possibly a remarkable case of cultural lag, which indicates that much more work should be done on the later historic painted wares of the Middle East (*7*). However, the possibility that the samples used for radiocarbon dating were contaminated cannot be completely ignored.

The second excavations took place during July and August 1962, at the rock shelter of Ghar-i-Mar (Snake Cave), located on a high terrace of the Balkh River in the limestone hills of the Hindu Kush mountains about 100 km south of Mazar-i-Sharif near the aforementioned town of Aq Kupruk. In a stepped trench, 24 m long by 2 m wide, I reached a depth of about 10.5 m (Figs. 1 and 2). The tentative sequence can be described briefly as follows.

Modern nomads still use the rock shelter for sheep and goat pens while moving through the area, and the upper levels consist mainly of sheep and goat dung.

The Early Islamic levels contain green and blue glazed sherds similar

to those found at other excavated Early Islamic (pre-14th century A.D.) sites in Afghanistan; for example, Shamshir Ghar, Balkh, Bamiyan, Lashkari Bazaar, and Ghazni. A heavily eroded iron knife of Early Islamic type was found, as well as several unidentifiable iron specimens.

Two Kushan (?) levels which underlie the Early Islamic apparently belong to the same general time period (6th to 7th centuries A.D.; Figs. 1 and 2), and represent periodic occupations as nomadic groups followed the Balkh River, once a major north-south route in Afghanistan. No glazed pottery occurs, but small bowls with a broad red band painted on the rim constitute the most common type of decorated pottery. Another ware, red with burnished wavy or straight-line patterns, found at Snake Cave, is common in other Afghan sites of similar ages. Other wares include: a buffish ware with wavy, comb-marked striations; a punctated and appliqued ware (one handle sherd has an appliqued pommée cross); and a crude, lime- and sherd-tempered ware with large storage jar and bowl shapes.

The most interesting feature of the probable Kushan complex consists of a series of retaining walls near the limestone wall of the rock shelter. Some walls were constructed with pisé (pressed mud), others with square mud bricks, each sun-dried brick measuring approximately 40 by 40 by 10 cm, and weighing about 10 kg. The underside of each brick bears diagonal or circular finger markings which help the brick adhere better to the mud plaster between the brick layers. A second cave is situated about 5 m above the rock shelter at ground level. To reach the upper cave, steps had to be cut in the limestone wall. The entire roof of the upper cave had been covered with a plaster base, and there Buddhist artists had painted colorful scenes in various shades of blue, red, brown, and beige. These paintings had been almost obliterated by generations of iconoclastic Muslims, but we collected fragments for analysis to determine whether or not there are any technical similarities between these and other Buddhist paintings in Central Asia. The paintings can be dated relatively accurately because the entrance to the upper cave has a wall of bricks, 1.5 m high, identical to those found in their original position in the Kushan levels. The period between the late 6th and early 7th centuries A.D. ties in very well with most other Buddhist paintings in Afghanistan.

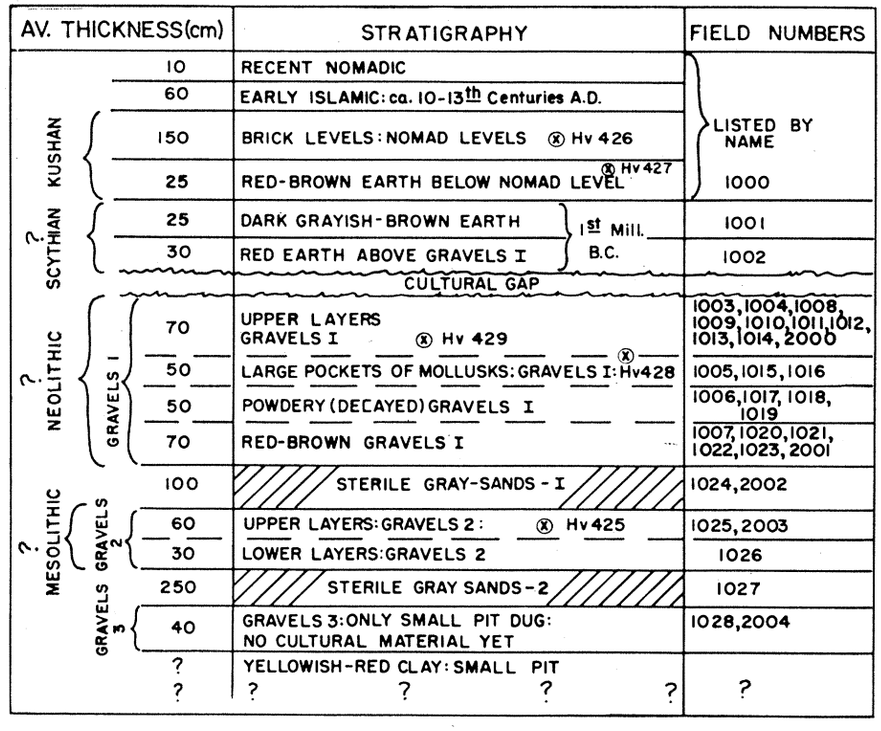

Fig. 1. Idealized stratigraphic cross section of Ghar-i-Mar (Snake Cave), Afghanistan. (Numbers to the right show the field numbers of the specimens; Hv indicates the catalog number of the charcoal sample.)

Other important Kushan finds included an almost complete two-bar wooden loom; textiles; basket fragments; querns; a wooden projectile point (probably for killing birds); and a snakeskin-covered wooden handle for a dagger or knife. In addition, several thousand animal bones, apparently from domesticated cattle, sheep, goats, and horses, as well as from wild goat and porcupine (*8*), were collected near the wall of the rock shelter.

Another Central Asian assemblage ("Scythian") occurred directly below the Kushan (*9*). No dates obtained by the carbon-14 method are yet available, so I have dated the finds on typological grounds as first millennium B.C. An interesting series of red-on-buff and black-on-buff painted sherds were found. Designs included free, flowing repeated spirals; wavy lines; and checkerboard. A polychrome ware with painted swastikas and fish (?) motifs was also present. Clay and carnelian beads were found, along with probable clay spindle whorls. Two classic "Scythian" bronze, trilobate, socketed projectile points were uncovered. Also present in the "Scythian" levels were several flint-end and side scrapers on blades.

An approximately 4000-year gap

Hv NUMBER	SAMPLES	AGE (Years before 1950)
Hv 426	CHARCOAL SNAKE CAVE 7/62 BRICK LEVELS, NOMAD LEVELS	1390 ± 60
Hv 427	CHARCOAL SNAKE CAVE 7/62 FIELD NO. 1000	1340 ± 70
Hv 429	CHARCOAL SNAKE CAVE 7/62 FIELD NO. 1013 GRAVELS I	7030 ± 110
Hv 428	CHARCOAL SNAKE CAVE 7/62 FIELD NO. 1015	7220 ± 100
Hv 425	CHARCOAL SNAKE CAVE 7/62 FIELD NO. 1025	8650 ± 100

Fig. 2. The ages of five samples which have been dated by radiocarbon methods at the Institute for Geology, Hamburg.

(1000 to 5000 B.C.) appears to exist between the upper gravels (Gravels 1) and the presumed "Scythian" levels. It is unlikely that the cave remained unoccupied for this period of time. Several meters of deposits could have been washed away in a short period of time, as indicated by the floods of 1963, which were the worst in the memory of the oldest living residents. Major portions of the main north-south road of Afghanistan were destroyed, as well as most minor roads. Hundreds of villages were flooded, thousands of acres washed down stream, and large segments of old river terraces disappeared. One such flooding in early postglacial times could have possibly removed several meters of strata on the terraces of the Balkh River.

Distinctive pottery (Neolithic), unlike that of the historic levels, appears in the upper layers of Gravels 1 which is probably about 7200 years old (Figs. 1 and 2). Two major types of pottery occur: a crude, soft, limestone tempered ware with simple rounded rims and flat bases, and a better fired ware with distinctive zig-zag incisions, which S. P. Tolstov of the U.S.S.R. Academy of Sciences pronounced to be similar to pottery from Russian Turkestan dating back to about 5000 B.C., a date tentatively corroborated by radiocarbon techniques (Figs. 1 and 2, Hv 428, Hv 429). Several sherds had markings made by fiber or basketry on the inner surface. The dominant flint tools were sickle blades, perforators, end scrapers, and blades. One possible angle burin (graver) was found, as well as several worked bone fragments. Several flint blade cores were also found.

Carbonized botanical materials, animal bones and several thousand mollusks remain to be analyzed, but the hundred-plus sickle blades indicate that at least wild grasses were collected. The bones have so far been identified as domesticated cattle, sheep, goat, and an onager (*8*).

The lower layer of Gravels 1 (nonceramic, Neolithic, and about 7500 years old) contained no pottery, and the powdery layer of Gravels 1 appeared to have been exposed for a long time, indicating that both layers are much older than the upper layers. Although I now call the lower levels "nonceramic," a planned widening of the trench may ultimately produce pottery. In the lower layers also, sickle blades occur in profusion, along with side scrapers on blades, points, burins, backed blades, and cores. One polished bone point was also found. A large pocket (about 50 cm diameter) of sheep or goat dung appeared in powdery layers of Gravels 1.

One meter of sterile sand (Sterile Gray Sands 1) separates Gravels 1 from Gravels 2.

In the upper layers of Gravels 2 (Figs. 1 and 2, Hv 425) (about 9000 years old) long, thin blades including some sickle blades, burins and end scrapers on blades were the primary products, evidence of the "Mesolithic" flint industry. Several thousand animal bones await identification.

A disconformity divides the upper layers of Gravels 2 from the Mesolithic (?) of the lower layers of Gravels 2. Hearths and animal bones occur in greater abundance in the lower than the upper layers of Gravels 2. The flint assemblage is more diversified: blade cores, microblade cores, end scraper-burin combination tools, blades, bladelets, burins, points, shouldered points, and keeled scrapers are found. The lower layers of Gravels 2 have not yet been dated by radiocarbon methods. Except that microlithic geometrics are absent and sickle blades rare (although they do occur), the industry appears to have resembled the "Mesolithic" Kuhbanan industry recently identified by Huckriede near Kerman, Iran (*9*).

A sterile series of thick (2.5 to 3 m) gray sands (Sterile Gray Sands 2) underlies the Mesolithic complex.

Just as the 1962 season ended, we encountered a third series of gravels (Gravels 3) near the rock shelter wall. A small cut (50 cm by 50 cm) penetrated the clayey gravels and produced nothing but a few animal bones. Below 40 cm of gravels, a yellowish-red clay appeared, and here we terminated our season.

These excavations are important for two main reasons. In Gravels 1 and 2 over 5000 flints have been found, of which over 1000 exhibit utilization, and primary or secondary retouching. Carbonized grasses were collected in the upper layers of Gravels 2 (estimated to be 8650 ± 100 years old by radiocarbon dating) and if these prove to be domesticated or transitional forms, we can consider the northern slopes of the Hindu Kush to be *one* of the centers of early agriculture. I suspect that the wheat-barley complex developed in a general longitudinal (34° to 40°N) zone at an altitude of 500 to 1500 m above sea level. The idea of agriculture could have easily and quickly spread across the foothills in any direction in this zone, because today a slow walker (15 km a day) can travel from central Anatolia to central Afghanistan in about 6 months.

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