gards calorific value there cannot be any serious difference between the two classes of coal.

In the Barnsley district proper, a certain thickness of the seam, sometimes amounting here to more than 40 per cent of the whole, the "Top-Softs" and the "Bags" as the upper portion is locally called, is very generally left behind in the goaf. Apart from its softness, it is a good coal; a sample recently tested in my laboratory gave a calorific power of 13,400 b.t.u. and 3.8 per cent of ash.

In Fifeshire the Great Seam 6 feet to 8 feet thick consists of about 2 feet of Ironstone, about as much common coal, and then about 3 feet of Cannel or Parrot coal. The latter alone is worked, all the rest of this fine seam being left behind in the goaf.

In Lanarkshire the Ell Coal, about 6 feet in thickness, is worked, and the Head Coal, about 2 feet in thickness, left behind in the goaf.

These few examples, taken somewhat at random, will serve to exemplify the nature of the loss of coal that is here discussed; in most cases the coal thus left behind must be looked upon as totally lost; in others it may be in part recovered. Thus some of the areas in Lanarkshire above referred to are now being worked over again, with the object of recovering as much as possible of the Head Coal previously rejected but obviously such an operation can never be a very satisfactory one. In many districts where there is one particularly

good or especially valuable seam, this is often worked out before any other seams are touched, without regard to the fact that such working damages other seams less valuable to-day, but nevertheless containing coal of quite good quality. The result of this damage is that a certain proportion, or possibly in some cases the whole of these other seams is rendered unworkable, and great loss of coal is thus brought about.

It is practically impossible to present any figures showing the amount of coal lost to the nation as the result of this deliberate waste, but it certainly amounts to enormous quantities in the aggregate. It is not easy to suggest any remedy for this loss; some authorities favor legislation, and the imposition of heavy taxes upon coal left behind has been suggested. This can hardly be looked upon as a scientific solution of the problem, and undoubtedly a better remedy would be the invention or the elaboration of methods of utilizing these inferior coals, which would give them a value sufficient to make it worth the while of colliery proprietors to work the whole of their coal. Some of these difficulties are unquestionably connected with our systems of mineral ownership, under which two seams within the same area may be let to different people, each of whom works for his own interests alone regardless of the interests of the neighbor above or below him. The importance of the question is very great and it undoubtedly deserves

the fullest possible investigation from every standpoint, there being probably no portion of the entire subject of coal economy that promises more valuable results.

I wish to state definitely that the all important question of safety is in no wise involved in the considerations here submitted, or rather that the reform of most of the sources of waste that I have indicated must result in increased safety for the coal miner. The diminution of gob-fires is obviously a case in point. Again, if it were possible to turn to good account the accumulations of fine coal dust, which constitutes such a grave danger in most of our collieries owing to the disastrous explosions to which it may give rise, the removal of this dust from the workings might readily become a source of profit instead of a loss as at present. It need hardly be said that such coal dust could, as has already been pointed out, be employed directly for firing, and that its cleaning and subsequent utilization should present no unsolvable difficulties. The coal left behind in the goaf is naturally also a source of danger to the coal miner, and in this way again the successful utilization of inferior coal would contribute to the safety of our collieries. The subject of safety is one of such supreme importance, that I have thought it advisable to refer specially to the fact that decrease in the present waste of coal would mean, if anything, a corresponding diminution of the risks to which the coal miner is exposed.

Zuni Chronology*

By Leslie Spier, American Museum of Natural History, New York

IN connection with ethnological studies in the southwestern United States, the American Museum of Natural History is conducting an archaeological survey of the same area. This provides the necessary background for a complete understanding of the ethnography of the region. While much energy has been expended in the Southwest, chiefly on the description of cultures, little progress has been made in the delineation of its culture-history through want of a chronology for the region.

The problem takes definite form when related to the ethnologic study of the social structure of the Zuni tribe now being made by Prof. A. L. Kroeber of the University of California. It is conceivable, for instance, that a far-reaching effect may have resulted from the concentration of the Zunis into a single huge community from their several villages of early historic times (the famous "Seven Cities of Cibola"). What can archaeological method tell us of the former groupings of these people, of their ultimate origin and their relations with other peoples? The answer to the problem rests on the establishment of a chronology which will order the confused mass of cultural data into a culture-history.

The possibility of attacking the problem in the vicinity of Zuni itself was made clear by the richness of the finds of the Hemenway expedition of 1888 under Cushing, Bandelier and Hodge, by a later hasty reconnaissance of the region by Fewkes in 1890,¹ and finally by Kroeber in a suggestive study incidental to his ethnologic work in 1915 which indicated the main direction the chronology would take.² The present study was undertaken by the writer in the summer of 1916.

The pueblos of the Zuni tribe occupy a strategic position for the study of the Southwest. They lie on the headwaters of the Little Colorado River in central western New Mexico, occupying a central location in the area. The two great areas of ruined pueblos lie one along the northern margin of the Southwest culture province in the drainage of the San Juan, the other along its southern margin in the Gila and Salt River watersheds. To the east, the occupied villages of the Pueblo Indians stretch along the Rio Grande, and from that center an extension of the modern culture including Zuni stretches westward into northern Arizona. We now have Nelson's partial chronology of the Tano tribe³ and Kidder's suggested sequences for the Pajarito plateau⁴ and for Pecos pueblo,⁵ all on the Rio Grande. A chronology from the western section of the pueblo area is therefore a desideratum.

The procedure involved in this task presents some novel aspects. Simultaneously in 1915, N. C. Nelson, A. L. Kroeber and A. V. Kidder arrived by three different inductive methods at the same conclusion, viz., that the characteristic Southwestern pottery was of the highest evidential value for the purpose of reconstructing the sequence of pueblo occupation, or, in the widest sense of the term, establishing a chronology. Their

methods of reconstruction were respectively stratigraphic observation of refuse deposits, the hypothetical ranking of surface finds and the observation of concurrent variations, and the hypothetical seriation of the several pottery techniques. Of these three methods, the advantages rest with the first, but its application in the case of Zuni finds was precluded by the shallowness of the refuse deposits at most of those ruins. The writer was therefore led to combine the two methods of stratigraphic observations and hypothetical ranking of surface finds.

Where stratigraphic observations could be made it was observed that the variable value of one fluctuating pottery type, "corrugated" ware (so named for its characteristic plastic decoration), could serve as an index of stylistic variations in the whole pottery art. On analyzing for their type content the samples of potsherds collected from the surface of ruins for 50 miles up the Zuni valley and from their refuse deposits, it was found that the resulting data fell into two groups. In both groups corrugated ware was present in the samples in amounts varying from 2 per cent to 60 per cent, but in each group the accompanying wares differed in type or in proportions, or both. For instance, samples of sherds collected from two ruins showed corrugated ware present in each to the extent of 40 per cent of the whole pottery art, but associated with this at one ruin was 60 per cent of a white ware, while at the other 23 per cent of red ware and but 37 per cent of white were found. For synthesizing these data we had at hand three premises: some of the ruins were claimed by the Zunis as their former villages and others were so mentioned in historic records; the whole group of ruins stand somewhat isolated from other groups in the Southwest, and finally, the decorations on the pottery found in them had sufficient individuality to set off the whole group from the rest of the Southwestern ruins.

To synthesize these data we had two guides. It became clear while making stratigraphic observations at the historic ruins that while corrugated ware is represented to the extent of only 2 per cent in historic ruins and in modern Zuni, it had played a larger rôle in the pottery art of earlier times. Similarly, the oldest remains in the valley showed an analogous variation in the use of corrugated ware, but in the opposite direction suggesting its coming predominance at a later period. Assuming then that we had here the end and the beginning of a stylistic pulse—an assumption made strongly presumptive by observed sequences in other sections of the Southwest—we ranked the data according to the ascending values for corrugated ware up to the maximum and then in descending order to the values for the recent villages. The validity of such procedure lies in the observed seriation of the accompanying wares: when a series of three or more distinct, but mutually dependent values are ranked according to some postulated sequence for one, and the other values are found to present serially concurrent variations, it may be safely concluded that the result is other than fortuitous. The results in this case amply justified the assumption. The fluctuations in the ceramic art of the Zuni thus stand revealed and are directly translatable in chronological terms.

The results obtained from the application of this chronology were the following:

1. The chronological scale itself shows a sequence of the pottery types, or rather of the predominating wares in the order of white, corrugated, red, black and with

the last buff and white. Of these black is a dull unslipped ware, corrugated shows the familiar indented coils, and the decorated wares are black-on-white, black-on-red, black and white-on-red, brown-on-buff and brown and red-on-buff, and the modern varieties of white ware. The sequence of the techniques parallels Nelson's for the Tano ruins in its general outlines: two-color and later three-color painted ware, two-color glazed ware, three-color combination glazed and painted ware, and modern painted ware, with corrugated ware appearing at all times and black ware in later periods.

2. The Zuni valley has been occupied continuously from an early period. The occupation has been transitory, no site being occupied for any considerable period. Certain major shifts of population are observable however: first to the northeast and east barely crossing the continental divide, later a return to the Zuni basin still occupied by the Zunis.

3. The Zunis first occupied single houses and later communal dwellings of the well-known pueblo type. The former are uniformly small, the latter rectangular or circular structures of considerable extent. It is not clear that the first type developed into the communal dwelling. This sequence of architectural types has been often postulated by older writers, but never proved.

The problem has then found a partial solution, inasmuch as we have traced the growth of Zuni communities and the ancient isolated character of their habitat. On the other hand the evidences for cultural isolation lie only in the development of such items as pottery designs of specifically Zuni character, the general nature of their culture-history as a whole showing a common growth with their Rio Grande neighbors.

The few data now at hand for the Southwest suggest a marked uniformity of culture throughout that area from the earliest times, with the gradual individualization by the several tribes of certain minor culture traits.

Whatever its specific results, this study has shown that the method of assumed seriation can be applied to archaeological phenomena. So far as the method is concerned, the novelty lies in its application to American culture-history.

The full data will be published in the *Anthropological Papers of the American Museum of Natural History*.

Modern Marine Dredges

DREDGERS can now deal safely and expeditiously with very difficult material such as sandstone, shale, lignite, stiff blue clay, or hard chalk. The Panama Canal being in a constant state of requiring attention from dredgers owing to the frequent collapses of the sides and bottom upheavals, it is interesting to note the type adopted in the canal zone. They are of the dipper 15-cubic-yard variety. Their ability to dig into and to dispose quickly of any of the softer rocks, even at a depth of 50 feet, and to load into scows of almost any size, makes them very valuable tools for this class of work. They are capable of dredging 7,000 to 10,000 cubic yards of rock per day of twenty-four hours, the quantity dredged naturally depending upon the hardness of the material. Each dredger has two dippers respectively of 10 and 15 cubic yards capacity, the dipper handle being 72 feet long. The main hoisting engines are of the twin-tandem compound type, and the winding drum is graduated so as to give a low speed when digging. The swinging engine is of the double-cylinder high-pressure type, with steam-operated link reversing gear.

*A paper communicated to the National Academy of Sciences by H. F. Osborn, and republished from the Proceedings.

¹Fewkes, J. W., *J. Amer. Ethn. Arch.*, Boston, 1, 1891.

²Kroeber, A. L., *Anthrop. Papers Amer. Mus. Nat. Hist.*, New York, 18, 1916; these Proceedings, 2, 1916, (42-45).

³Nelson, N. C., *Amer. Anthrop.*, N. S., 18, (159-180).

⁴Kidder, A. V., *Memoirs Amer. Anthropol. Assn.*, 2, (407-462).

⁵Kidder, A. V., Proceedings of the National Academy of Sciences 2, 1916, (119-123).