mathematics; Dr. Stuart R. Brinkley, chemistry; Roscoe H. Suttie, civil engineering; Archer E. Knowlton, electrical engineering; Everett O. Waters, mechanical engineering; Arthur Phillips, metallurgy, and Dr. Blair Saxton, chemistry. Instructors who were promoted to assistant professorships are: Dr. Robert De W. Coghill, chemistry; Lauren E. Seeley, mechanical engineering; Dr. Richard F. Flint, geology; Dr. Lucius T. Moore, mathematics; Dr. Jesse W. Beams, physics. Dr. Dirk Brouwer has been appointed research assistant in mathematical astronomy.

AMONG those who will give courses at the summer quarter of Stanford University are: Dr. Harry Clark, associate member of the Rockefeller Institute, in physics; Dr. Alfred Errera, of the University of Brussels, and Dr. Carl Einar Hille, of Princeton University, in mathematics; Dr. J. J. Runner, assistant professor at the University of Iowa, in geology, and Professor Edward A. Bott, of the University of Toronto, in psychology.

DR. ROBERT ROBINSON, professor of organic chemistry at the University of Manchester, has been appointed to the chair of organic chemistry in University College, London.

DR. GEORGES FONTÉS has been appointed professor of biological chemistry at Strasbourg, and Dr. Arnt Kohlrausch, of Greifswald, professor of physiology at Tübingen.

DISCUSSION AND CORRESPONDENCE

A PERIODIC CLASSIFICATION OF THE HARDNESS AND MELTING-POINTS OF THE ELEMENTS

IT is possible to classify the elements according to hardness and melting-point, and this classification fits with considerable precision into an eighteen-period table based on spectroscopic similarities.

The table (see Fig. 1) represents the elements arranged according to atomic number, with those of similar spectra in columns. The columns under H and He represent the first stage in the building-up of the electron structures of the atom, that of building on the two "s" electrons; the six following columns add the "p" electrons, while the long group from Sc to Zn all contain elements to which the "d" electrons are being added. Thus at the end of each column we have the complete shells; the "s" shells under He, the "p" shells under the rare gases, and the "d" shell under Zn. Lanthanum and the 14 Rare Earths come under Y. These represent the "f" electron being built on.

Let us first consider the melting-points. If we examine the table, we find some striking characteristics. In the first place, all the elements with high-melting points are at one end of the table, while those with low melting points are at the other. Then let us examine the columns. For each column under Sc, Ti, V, Cr, Mn, Fe, Co, Ni, the melting-points increase down the column. Under Cu all are nearly equal. Under Zn, B, C, there are minima at Hg, Ga, Sn, respectively. The N column has a maximum at As. The melting-points under O, F, Ne, all increase down the column. It is interesting to note that the permanent gases conform to this periodicity as well as the non-gases. The alkali metals decrease in melting-point down the column. Under Be there is a minimum at Mg. The only discrepancy is Ti, whose melting-point is slightly above what we should expect.

Another interesting characteristic is that the whole first long period row (Sc–Cu) have similar melting-points, falling off slightly at either end. The same is true for the next two rows.

Turning to the subject of hardness, we find that this in general varies as the height of the melting-point. It is of course difficult to obtain accurate values for absolute hardness but considering some recently obtained by A. Mallock,[1] and others, we note that all the hard metals are bunched, as are the soft ones. The maxima and minima are in the same places, and the runs follow the same sequences as do the melting-points. The discrepancies are, V, and Pd; but Mallock claims the V was not obtainable pure in the proper form for the test, and Rydberg[2] claims that

[1] A. Mallock, *Nature*, Feb. 19, 1927, p. 276.

[2] Rydberg, *Zeits. f. Physikalische Chemie*, 33 (1900) 353–9.

																	H	He
																	Li	Be
											B	C	N	O	F	Ne	Na	Mg
											Al	Si	P	S	Cl	A	K	Ca
	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	Rb	Sr
	Y	Zr	Cb	Mo	Ma	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	Cs	Ba
La and 14)		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	85	Rn	87	Ra
Rare Earths)		Th	Ux	U	93													

FIG. 1. Table of the elements, arranged with regard to spectroscopic similarities, in order of atomic number. Inspection will show how hardness and melting-point fit in, the harder ones being at the middle of the (left) long period.

Pd and Fe are about equally hard, as we should expect. That C, B, Be, and others are hard, while Cs, Rb and P are soft is well known. We see, therefore, that hardness is quite well expressible in the same curve as melting-point.

We have, then, an interesting correlation. The spectroscopic properties and the melting-points and hardnesses are expressible in the same table. And as the agreements on the whole are so good, holding not only for metals, but for non-metals and gases, we might venture to predict the characteristics of those whose melting-points and hardnesses have not yet been determined. Thus we suggest that 85 (Eka-Iodine) will melt at about 250° C. and be fairly soft, and that 87 (Eka-Caesium) will melt at about 18° C., and be very soft. Number 93 will be hard and of high melting-point, coming as it will below Re. We also suggest that the value of Masurium, assumed in the International Critical Tables to be 2,300° C., will be nearer 2,500° C.

It is evident from the foregoing that there exists a relation between the electronic configuration and the melting-point and hardness. We notice that the atoms with the complete shells have the lowest melting-point. Those with a partial shell, such as W, Re, and Os, where about half the "d" shell is on, have high melting-points, and are hard. The "irregular" atoms, whose electron shell structure, and in particular, whose outer shell is incomplete, thus have greater mutual attraction, and less yielding to deformation of the solid configuration than those with complete shells. The deformation of a substance by shear and compression forces (the method of testing hardness) is thus quite similar in its fundamental effect on the atoms of the substance to the deformation in melting; atoms sliding on atoms more readily if the atoms have complete shells. There is evidently less stray field holding these complete shells together. Hence in the central part of each period we find the harder elements and the soft ones at the ends. This, according to our interpretation of the table, means that the elements increase in hardness as more electrons are built on, attain a maximum somewhere before half the shell is completed, and fall off in hardness as the shell nears completion to a minimum at the complete shell.

S. A. KORFF

PRINCETON UNIVERSITY

FURTHER EVIDENCE CONCERNING MAN'S ANTIQUITY AT FREDERICK, OKLAHOMA

IN SCIENCE of February 10 appears a note by Dr. Leslie Spier, of the University of Oklahoma, questioning certain phases of the evidence bearing on man's antiquity at Frederick, Oklahoma. The geological age of the deposits, their nature and occurrence, are well established and not questioned. He states however, "The artifacts themselves are equivocal," and questions their occurrence and contemporaneity with the fossils; and their Pleistocene age.

In relation to their authenticity as human implements, according to his own statement therein, *i.e.*, "— I have not seen the originals," he is hardly in a position to speak with authority on the matter, especially in the face of the fact that no one who *has* seen them has questioned their authenticity as human artifacts.

Dr. Spier particularly questions the grinding stones to which we have referred as "metates," in describing them. It would appear that his objection may be based on our choice of name for them, or upon a misunderstanding as to how such grinding stones were used by nomadic, non-agricultural Indians,—uses to which his published remarks would indicate a lack of familiarity. In regard to this matter, the writer has in his personal collection a number of such grinding stones from the region near the Black Hills, South Dakota, which were used by the Sioux Indians of that region when the writer first knew them as a boy. These Indians did not raise or use any sort of grain or cereal, and were a nomadic, hunting race; yet they did use, until they secured better implements and food from the white man, "metates," or grinding stones, of the type found at Frederick, Oklahoma. They used these at semi-permanent camp sites for crushing and breaking up dried fruits, (such as cherries and plums), dried meat, "Indian 'turnips,'" and other dried roots and plants which they dried and cured for winter use, much of which dried exceedingly hard.

It is entirely probable that in this, as in many other instances, need and a similar environment have caused different peoples at widely separated times and places to do similar things independently and reach similar results; and it certainly is not, in itself, and unsupported, evidence of racial homogeneity. It can equally well be, and probably is, another case of parallelism. I have personally seen these stones so used many times, and now have some of their dried foods as well as grinding implements in my private collection. Therefore, the argument that such could not have great antiquity, because, "All Americanists are agreed that cereal raising is not one of the original constituents of Indian culture" is without value. Beyond this, what "Americanist," or anyone else, for that matter, is in a position at this time to speak with authority of the habits or customs of any race