Although Bernal's "fundamental interest lies in the history of a civilization, not in its archeology," he expertly covers Olmec architecture, sculpture, and ceramics. Description is augmented by 40 drawings and over 100 photographs. The archeological data serve as a factual basis upon which to make inferences about the nature and history of Olmec society. The formulation is the most ambitious attempt yet to bring alive the Olmec civilization.

The innovative Olmec produced one of the great early art styles in all human history. It is likely that they developed a writing system, positional numbers, and a calendar, and forged an empire as well.

The strength of Bernal's work lies in the plausibility of his deductions from the archeological record. No Phoenician galley, Egyptian dhow, Polynesian raft, or Chinese junk is conjured up as a model for the Olmec ship of state. The explanation for the rise of the first New World civilization is at once more simple and more reasoned than transoceanic origin: it is the genius of the Olmec confronted with a challenging environment. But which environment? That is the question. Was it the Mexican plateau or the jungle lowland?

About a millennium before Christ—Bernal says 1200 B.C.—there appeared along the Gulf Coast of southern Veracruz and northern Tabasco ceremonial centers with truncated pyramids, spacious courtyards, jade-rich tombs, and a sophisticated sculptural style. Aside from technical proficiency and esthetic impact, the content of Olmec art attests to a profound religiosity embodied in the jaguar cult. Through trade, proselytism, conquest, or combinations of these, the cult of the jaguar and its connected art style spread throughout the culture area of Mesoamerica, covering central and southern Mexico and northern Central America. Bernal's tripartite division of the Olmec into Metropolitan, Colonial, and Olmecoid is an attempt to create meaningful units for analyzing this diffusion.

As Bernal notes in passing (p. 107), my views as to the origin of Olmec style differ from his. Bernal accepts "the hypothesis of the birth of civilization on the tropical coast," ruling out the possibility of highland origins because "there are no antecedents there." I do not see that Bernal has made a case for antecedents on the coast. For me his Olmec I period has nothing Olmec about it and the Olmec arrive on the coast fully formed in Olmec II. (The latter I would have start at 1000 rather than 1200 B.C., thus following Heizer's radiocarbon dates for La Venta, which seem to offer a better fit within the overall Mesoamerican sequence than do Coe's for San Lorenzo.) This would mean that the original challenge to Olmec genius was not the tropical forest, as Bernal holds, but rather the semiarid highlands where plant domestication occurred and where irrigation works constituted an appropriate response. Furthermore, as I see it the evolution of the Olmec style shows the earlier works of art as coming from the highlands.

Because of this position I cannot accept the division of Metropolitan, Colonial, and Olmecoid. There are no metropolises in Olmec times anywhere in the New World. The word "colonial" pertains to colonies under the control of a parent country, but where is the parent country: on the coast or in the highlands? Tlapacoya in the Valley of Mexico looks much more Olmec to me than it does to Bernal; it also appears closer to being a metropolis with a large resident population than does the coastal ceremonial center of La Venta.

Like Bernal and me, all Mesoamericanists of necessity are divided into "highlanders" and "lowlanders" when the origin of civilization is debated. This makes for one of the most fascinating controversies in New World archeology. Its existence adds to the appeal of Bernal's book, for the reader can form his own opinion. At the same time, all will agree on the greatness of the Olmec accomplishment. The Durants' *The Story of Civilization* and Toynbee's *A Study of History* obviously have not told the whole story. Bernal's lucid synthesis of the evidence for the most ancient of American civilizations serves to fill the gap.

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Petroleum Geochemistry: A Russian View

Transformation of Petroleum in Nature. P. F. ANDREEV, A. I. BOGOMOLOV, A. F. DOBRYANSKII, and A. A. KARTSEV. Translated from the Russian edition by Robert B. Gaul and Bruno C. Metzner. E. Barghoorn and S. Silverman, Transl. Eds. Pergamon, New York, 1968. xvi + 468 pp., illus. $18. International Series of Monographs in Earth Sciences, vol. 29.

Soviet research on the geochemistry of petroleum has probably been more extensive than that of any other country except the United States, where, unfortunately, many of the data that have been obtained are buried in oil company files. Consequently, the translation of this monograph, which was carried out with National Science Foundation support, makes a valuable contribution to the Western literature. The authors are four of the leading petroleum geochemists of the U.S.S.R., and their book has long been recognized within their country as the leading treatise on this subject.

The real strength of the book lies in the wealth of data it presents, from both laboratory experiments and studies on numerous Soviet oil fields. About one-fourth of the data are new, the rest having been previously available to geochemists with the facility and fortitude to read Russian journals. The reader also receives a clear picture of how these data led the authors to their present ideas about the origin and alteration of petroleum.

The objective of the book is to throw light on questions connected with the transformation of petroleum, and it does this in a logical manner, starting with a summary of existing geological information on the habitat of petroleum and proceeding to a discussion of the thermodynamic transformation of petroleum constituents, including thermocatalytic reactions. The basic concepts of the authors are in agreement with those of most Western geochemists who have worked along similar lines.

For example, Dobryanskii prefaces the text with the statement, "Although there can be no question about the organic origin of the source material of petroleum, the chemists have not yet established the mechanism of the transformation of this material into hydrocarbon mixtures. However, there is no question about the general thermodynamic direction of the process." In the opening chapters Kartsev devotes a few pages to discounting hypotheses postulating an inorganic origin

for petroleum, an exercise which most petroleum geochemists have periodically gone through. Kartsev's approach is refreshing in that he cites several examples of Soviet oil accumulations which effectively put to rest the theories of inorganic origins.

The main hypothesis of the Russian authors is that petroleum starts out as a heavy dispersion of mobile, hydrocarbon-like compounds which are then transformed during diagenesis at increasingly greater depths of burial into lighter hydrocarbons with a corresponding hydrogen deficient residue. Thus shelf oils which have not been subjected to very great depths of burial or regional metamorphism tend to be heavy as compared to oils accumulating in highly folded regions.

The phenomenon of the metamorphism of petroleum with age and depth of burial is handled rather interestingly by Kartsev in terms of the "geotectokhronobat," a factor which takes into consideration the depth of a petroleum accumulation, the absolute age of containing sediments, and a parameter characterizing the degree of metamorphism of the particular region. Geotectokhronobats are calculated for about 60 petroleums, mostly Russian but including a few from foreign fields. Kartsev also uses a vector diagram adapted from Vassoevich for visual representation of the effect of geological factors on petroleum properties.

Andreev presents several effective arguments for applying thermodynamic processes to the analysis of the formation and change of petroleum under natural conditions in two central chapters of the book. He demonstrates that the disproportionation of hydrogen from the very large molecules to the very small molecules leads ultimately to the formation of very light gases and pure methane plus graphite in the last stages of metamorphism. In general, the thermodynamic probability of redistribution of hydrogen increases with the complexity of the molecule. Andreev's chapters constitute the most detailed discussion of hydrocarbon transformation at low temperature available in the geochemical literature.

Mechanisms of oxidation of accumulated oils by meteoric waters are discussed in some detail by Kartsev and Andreev, with the latter providing thermodynamic data on the reactions.

The phenomenon of migration of a mobile hydrocarbon phase from source to reservoir rock is treated very lightly with the admission that we just don't understand it. The authors consider vertical migration through a basin as negligible, and vali l reasons are given for ways in which migration cannot occur. Most Western geochemists would agree with the Russians' statement, "The migration of petroleum from clays is a very complicated and debatable question and is one of the weakest aspects in the theory of the formation of petroleum from dispersed organic material."

Bogomolov contributes most of the data on the thermocatalytic conversion of both hydrocarbons and nonhydrocarbons to low-molecular-weight fractions of crude oil. A host of specific examples are given of the thermocatalytic conversion of aromatic, naphthenic, and paraffinic hydrocarbons. Bogomolov arrives at several important generalizations concerning the composition of the products as a result of these experiments.

Although a book like this does not become outdated in terms of the experimental data, it is unfortunate that all of the experiments cited and most of the references are prior to about 1958. This was recognized by the authors when the translation was planned, and both Bogomolov and Kartsev requested that some of their more recent papers through 1962 be cited. Nevertheless, the rapid advance made during the last decade in gas chromatography and mass spectrometry methods would make it possible to detect reaction products with a precision at least an order of magnitude higher than at the time this book was written. For example, Dobryanskii points out in the closing chapters that "experimental verification of the hypothesis concerning the transformation of petroleum aims at reproducing in the laboratory the natural process to which petroleum is subjected in the depths of the earth. Experiments with various hydrocarbons and their mixtures are carried out at the lowest temperatures at which the changes susceptible to analysis could still be reliably noted." The temperature range at which most of the Soviet experiments were carried out was about 150° to 450°C. Similar types of experiments are being carried out today in the ranges of 75° to 125°C, from which one can make more realistic extrapolations to natural conditions. Dobryanskii recognizes the problem and discusses it in some detail. It may be that even now the Russians are supplementing their previous work with lower-temperature studies.

The final chapter by Dobryanskii contains a useful set of nine conclusions regarding the transformation of petroleum in nature. Of particular interest is a diagram showing the hypothetical group composition of petroleum as a function of degree of conversion as it goes through the entire process of metamorphism.

The book is more readable than many Russian translations, thanks largely to the efforts of the translation editors, E. Barghoorn and S. Silverman. Both editors are thoroughly familiar with the subject, and their comments at various places add to the usefulness of the text. The book is highly recommended to anyone having an interest in petroleum geochemistry.

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Plant Ecology

Principles of Dispersal in Higher Plants. L. VAN DER PIJL. Springer-Verlag, New York, 1969. viii + 156 pp., illus. $9.

Intended as a companion volume to *The Principles of Pollination Ecology* (1966) by K. Faegri and L. van der Pijl [reviewed in *Science* **155**, 65 (1967)], the present work is an invaluable addition to the literature on reproductive biology of plants. Dispersal and pollination biology, long in disrepute, is only now coming back into vogue. Van der Pijl's slim, compact volume is the first comprehensive treatment of the subject in English since H. N. Ridley's monumental, and still indispensable, classic *The Dispersal of Plants throughout the World* (1930).

Few botanists today are better qualified than van der Pijl to write on dispersal (and pollination) biology. A treatise of high caliber would be expected, and this latest effort is no disappointment. The author has an intimate knowledge of tropical phenomena in general and of tropical reproductive biology in particular. This book is markedly free of the north temperate bias that characterizes so many of the European works. Tropical examples of dispersal are used extensively throughout the text.

Useful introductory chapters on general terminology, on dispersal units, and on relationships between the various