

slates and sheets of amygdaloidal diabase. At the time of the sinking the whole of the core, about a mile in length, was carefully labelled and preserved on the property in a specially constructed core house.

The limited time at my disposal will not allow me to recapitulate more than a few of the important services rendered in recent years to mining by geologists. But mention must be made of E. J. Dunn's and T. A. Rickard's work on the Bendigo gold fields and their exposition of the true nature of the remarkable saddle-reefs, whose tectonic structure has determined a type of mine development quite peculiar to that field.

Again, S. F. Emmons' monograph on the structure and genesis of the Leadville silver-lead ores has been of enormous value to the Colorado miners, not a few of whom owe their success on that field to the predictions of the distinguished economic geologist whose recent demise we must all deplore. On the other hand, the theory favored by Emmons that the ores were derived from metals leached from the overlying porphyries and the consequent conclusion that the lower limestone would on the whole be unproductive, have probably somewhat retarded the deeper development of the district. These lower horizons, however, have latterly proved to be very productive as will be shown in the new edition of the Leadville Monograph now in course of preparation. Emmons' researches on the deposits of silver-lead ore in limestone at Leadville incidentally led him to develop the theory of metasomatism, or replacement, as a prime factor in the genesis of ore deposits. Of this more anon.

Another worker in the same field, and, moreover, a friend of Emmons and long a colleague on the United States Geological Survey, is George F. Becker, whose classical studies on the famous Comstock lode and its high-temperature thermal springs have done so much to demonstrate the close genetic connection between ore deposition and vulcanicity. Becker's monograph on the geology of the Comstock lode was issued in 1882, and in one of the opening chapters he pays a remarkable tribute to Baron Ferdinand von Richthofen, who examined the Comstock in 1865 for the Sutro Tunnel Co., at that time engaged in driving a deep level adit to the lode at a depth over 1,000 ft. vertical below the then existing workings. The German geologist had a keen insight into structure, and although the mines were, when Becker wrote, about six times as deep as they were at the date of von Richthofen's report, the later investigator states that the opinions and predictions of his predecessor as to the behavior of the lode in depth had been verified in a very remarkable manner.

The United States not only is rich in great natural repositories of mineral wealth, but is fortunate in its economic geologists, whose keen observation and powers of deductive reasoning are admirably adapted to the study of their structure and genesis. That this is no idle saying witness the splendid series of monographs and professional papers issued by the United States Geological Survey. I have referred to the work of Emmons and Becker; there are many others. To mention a few only: R. D. Irving, who wrote on the Copper-bearing Rocks of Lake Superior; Lindgren, on the Copper Deposits of the Clifton Morenci District, Arizona; Weed, on the Geology and Ore Deposits of the Butte District, Montana; Lindgren and Ransome, on the Geology and Gold Deposits of the Cripple Creek District, Colorado; Van Hise and Leith, on the Iron Ore Deposits of Lake Superior.

Willet G. Miller's work in the Cobalt silver district also deserves mention. His description of the characteristic features of the silver veins right at the beginning of the mining operations of that camp was of first importance; and his early recognition of the bearing of the Keewatin series, which underlies the Cobalt conglomerates, on the life of the mines exercised a salutary chastening influence.

The laborious nature of the task of collecting and collating the material for memoirs such as these is well illustrated by the introductory remarks to Mr. Weed's Butte paper. The complexity of the geological structure of the Butte district necessitating very detailed observations; "in every mine, maps of each level were transferred to notebooks, and with these in hand the writer and his assistants carefully examined the drifts and crosscuts and plotted on the maps the occurrences of each slip, vein or fault, noting the dips, strikes and other important features. Stopes and raises were noted in the same way and sketches made of particular features of vein structure and ore occurrence." Over a hundred miles of underground workings were examined in this manner.

Hitherto I have confined my remarks to lode mining; but in the field of alluvial mining the economic geologist has also something to say. The fascinating task of tracing out, first by boring and then by drifting, the auriferous gravels of an ancient river system, deeply buried under a pile of more recent accumulations, which sometimes even include thick sheets of basaltic lava as in the Loddon valley at Ballarat, must have called for considerable geological acumen. I am unaware to whom the credit for the first discoveries of this nature in Australia and California is mainly due, but mention must be made of the work of Reginald A. F. Murray in Victoria and of R. L. Dunn and Ross E. Browne in California. I should also like to direct attention to Lindgren's remarkable reconstruction of the ancient (Tertiary) topography in the vicinity of Nevada City and Grass Valley in California.

The assistance rendered by geologists in prospecting for petroleum is well known to you. The earliest investigations of petroleum fields, dating back to the middle of last century, led to the conclusion that great natural reservoirs of oil and gas tend to form along the axes of anticlinal folds or at the top of domes; it was also observed that the best conditions for oil accumulation were those of gentle folding, sufficient indeed to give a gradient along which the oil and gas could travel in the porous bed, but not intense enough to cause fissuring in the impermeable cover. It must be conceded that the general correctness of this theory has been confirmed by the work of subsequent observers, and it will also be noted that the "anticlinal theory" is not quite as novel a conception as some of our friends would have us believe.

There can be no doubt that the search for these natural products is essentially a geological problem, and, to my mind, the fundamental qualifications for what is euphemistically termed "the oil expert" are sound geology and common sense.

I shall refer later on to the important bearing on mining—especially on the mining of copper—of the researches of mining geologists on the origin of ore deposits, and notably in regard to the phenomenon of secondary enrichment.

Enough has been said to indicate the dependence of mining on geology; but that this dependence is not universally admitted is evidenced by the prejudice against both the mining geologist and the scientifically