All of these, excepting a small part of the SiO_2 which may be derived from the wall-rocks, are probably contributed by the great batholiths that have at various times intruded the older rocks. There is evidence of various periods of mineralization, and no doubt the ore solutions were different, but at all times the metals were likely present as sulphides in solution in magmatic waters, which contained enormous amounts of alkali sulphides and hydrogen sulphide, with some carbon dioxide, boric acid, and fluorine.

Conditions, Time, and Methods of Deposition.

The presence of garnet and epidote indicates that the lower part of the deposits as now found was formed under contact-metamorphic conditions with high temperature and pressure. The upper parts of the deposits were formed under hydrothermal conditions and medium temperatures. The last minerals to form—namely, the zeolites and calcite—crystallized at fairly low temperatures. Wohler gives a temperature of 180° C. as that necessary for the formation of apophyllite. Apparently then the ores were deposited by solutions at high pressure and temperature which, as they moved upward along the fracture-zones, became solutions of medium temperatures with mineralizers, such as fluorine, hydrogen sulphide, etc. The fall in temperature and pressure resulted in deposition of part of the material in solution. This was no doubt aided by the reactions between the wall-rocks and the ore-bearing solutions. If the retention of the metallic sulphides depended on the presence of potassium in the waters, the removal of that element by the biotitization of the country-rocks would necessarily cause the deposition of part of the ore-minerals.

The origin of these solutions carrying such large amounts of alkaline sulphides along with carbon dioxide and fluorine must have been magmatic. As previously shown, there were at least two periods of mineralization. The first period probably corresponds to the closing activities of the Jurassic batholithic intrusions that ended with the intrusion of the great mass of normal monzonite. The later more alkaline magma of the pulaskite invasion introduced a much smaller amount of sulphides, but by its high alkaline content it would be capable of carrying considerable amounts of gold, and to it is attributed the production of the richer zones in the older deposits and the very rich impregnations that are found near pulaskite dykes.

The history of the ore-deposits may be summarized as follows The batholithic invasions of Nelson granodiorite, diorite porphyry, and monzonite were accompanied by fracturing of the older rocks by a somewhat torsional stress. In these fracture-zones the solutions and emanations from the cooling magma deposited rather low-grade sulphides. The intrusion of the Tertiary alkali syenite (pulaskite) batholith was accompanied by a second fracturing which largely followed the earlier shear-zones. In these the highly alkaline solutions from this intrusive deposited sulphides which were much richer in precious metals than the Mesozoic sulphide-deposition.

Secondary rearrangement by descending waters has had but little effect on the Rossland deposits. Primary sulphides were found practically at the surface. Along wet seams a little malachite has developed, but as these seams do not extend to a great depth the main mass of the deposits is entirely unaffected. Ground-water stands at about 50 feet, and from that level to about 400 feet the amount of water pumped increases. In this zone flat diamond-drill holes are always wet and same carry a large flow of water. Below the 400-foot level the amount of water steadily decreases until at 1,000 feet the workings are practically dry and no pumping is necessary.

PETROGRAPHY OF THE IGNEOUS ROCKS.

The great batholithic or laccolithic intrusions affecting the Rossland district fall into two groups—the earlier Mesozoic period of augite porphyrite, monzonite, and granodiorite intrusives, and the Tertiary period of more acidic character represented by alkali syenite and granitic rocks with some dykes of a more basic character.

ROCKS OF THE BATHOLITHIC INTRUSIONS.

Augite Porphyrite.

The augite porphyrite in the hand specimen varies considerably in appearance. It is usually greyish to greenish black, with prisms of dark-greenish pyroxene visible to the naked eye. They are usually nearly square. They vary in size and may become so small as to be unrecognizable.