

run parallel for many miles before rejoining the fissure zone south of Stanislaus River. One of the factors (viz., the presence of carbonaceous slates) that makes Mother Lode mine is therefore lacking in Angels Camp.

While, therefore, any given fissure of the Mother Lode series may cease to yield ore in depth, it is probable that ore will be found at greater depth in another adjacent member. Finally, when broadly considered, the Mother Lode may, with unchanged geological conditions, be expected to carry ore with undiminished tenor to and perhaps beyond the limit of "depth" set forth in this paper.

No evidence of value is to be derived from a study of the gold veins of the Urals. They are nearly all small and irregular and no deep mining has been done on them.

Reviewing the scanty evidence furnished by the granodioritic group, we find for Eastern Australia a gradual though small diminution of the tenor of ore bodies in depth, while on the Mother Lode all the evidence points towards a general persistence in depth for typical Mother Lode mines. A mining engineer, dealing with the future of these mines, would not, therefore, unless he had evidence of an approaching change in geological conditions, be justified in disregarding all ore except that "in sight"; some might be expected to occur below the deepest present explorations, and such ore should always be taken into economic consideration.

Pre-Cambrian Goldfields.

The third group of the classification includes all Pre-Cambrian goldfields and comprises the most important now being worked. These lie in two geographical areas, one on the borders of the Indian Ocean, ranging from Western Australia through Southern India and Egypt to Rhodesia and the Transvaal, and the other along the eastern side of America from Eastern Canada through the Appalachian chain and the Guianas to Brazil and Tierra del Fuego. The former is a very well defined group of goldfields that, though geographically widely separated, present so many points of similarity that a geological description of the various rocks and of their internal relations in any given region would serve, with the mere change of place names, for any other region of the group. The members are consequently believed to form a single petrological and metallogenetic province, for which the appellation Erythraean* has been suggested.

A typical Pre-Cambrian field is that of Kalgoorlie in Western Australia. Its total gold production has been more than forty millions sterling. It has been closely studied by the writer and throws considerable light on the general question of auriferous deposition in Pre-Cambrian rocks and on the persistence of ore in depth in those rocks. Briefly, the area is one of ancient schists (mainly calc-schist) through which a quartz-dolerite magma with its differentiation products has intruded. The differentiation sequence appears to have been quartz-dolerite (quartz-diabase) followed first by members as basic as peridotite and then by more acid segregations ranging through porphyrite to final albite-porphyry, the last being often intrusive through the quartz-dolerite. Auriferous impregnation followed closely on the intrusion of the albite-porphyry. Rich lodes have been developed only in shear-zones in a broad dike of quartz-dolerite, the shear-zones being barren when they pass in depth or in linear extension out of the quartz-dolerite. Since the shear-zones are, when considered over depths of

3,000 feet, approximately vertical, and the quartz-dolerite dike, which is parallel to the strike of the shear-zone dips west at 65 degrees, the shear-zones pass in depth out of the dike, the eastern shear-zones with their contained lodes reaching barren ground sooner than the western (see plan and section). Kalgoorlie, therefore, well illustrates an outstanding feature of all goldfields, except indeed some in the Tertiary group, viz., that non-persistence of ore in depth is a function not of depth but of geological structure. In Kalgoorlie three well defined parallel shear-zones may be made out. Taken severally and having regard to the depth factor alone, they show (a) non-persistence of ore in depth (Australia East and Lake View-Perseverance lodes), (b) persistence of ore in depth (Great Boulder and Ivanhoe-Horseshoe lodes), and (c) a probable enrichment in depth (Ivanhoe West lode). Generalizations based on the depth factor alone when geological conditions are unknown are misleading. Rickard,† for example, has relied on the evidence furnished by the failure in depth of the eastern lodes and an impoverishment in the Ivanhoe mine at 2,500 feet to support a general theory of impoverishment in depth. Garrison‡ also quotes the Ivanhoe impoverishment as possible evidence of non-persistence in depth. The Ivanhoe impoverishment does take place, but it is local and is due to the fact that the vertical Ivanhoe lode here passes through a thin albite-porphyry dike dipping west about 65 degrees. The great Boulder lode passed through the same dike with local impoverishment at 2,200 feet. When, however, the latter lode was encountered beneath the albite-porphyry dike it proved as rich as in upper levels, and the same result may reasonably be expected in Ivanhoe deeper levels. So far, then, as the evidence furnished by Kalgoorlie goes, it indicates that, so long as its lodes remain in quartz-dolerite, so long will they furnish ore equal in tenor to that found from the 500 to the 2,000 ft. levels. The Horseshoe-Ivanhoe group of lodes may therefore be expected to carry ore to the 5,500 ft. level, provided always that the quartz-dolerite dike persists, does not flatten in dip, and is not thrown westward in depth by westerly dipping reversed faulting.

Archean strata, from the vicissitudes to which they have been subjected in the course of long geological ages, are normally much folded and disturbed, while lode fissures in them are nearly vertical. It is a fundamental axiom in these older deposits that the nature of the lode wall exercises a vital influence on the richness and sometimes on the mineral character of the ore body. Hence it rarely happens that a great depth is reached before the lode, worked from the outcrop downward, has passed out of the favourable rock. A notable exception is the Champion Reef of the Kolar goldfield, southern India, probably the richest single gold lode ever worked. From 3,200 to 3,800 feet ore as rich as any obtained in the upper levels is now being worked and ore may be expected to persist in this fissure as long as it remains in the favourable hornblende-schist.

The greatest goldfield of the world, viz., the Witwatersrand, responsible for 37 per cent. of the world's gold production, is a Pre-Cambrian goldfield, but the criteria of ordinary Pre-Cambrian fields do not apply to it. Its deposits lie in sedimentary quartzites and conglomerates and are undoubtedly decreasing in tenor in depth. Having regard to all the geological conditions surrounding auriferous deposition on this field, it may be assumed that its gold was deposited relatively near the then existing surface and that deposition was due either to cooling on approach to the

*Maclaren, Trans. Inst. Min. Met., Vol. XVI., 1907, p. 15.

†Min. Sci. Press, Aug. 31, 1912, p. 264.

‡Loc. cit., Nov. 30, 1912, p. 701.