

always a sharp line of demarcation between the mica-schist and the granite.<sup>22</sup>

In the same region the granite boss of Shap has produced some interesting changes on the andesitic and rhyolitic lavas and tuffs associated with the Lower Silurian strata. These changes have been studied by Messrs. Harker and Marr, who describe the gradual alteration of the andesites by the development of brown mica, hornblende, sphene, and other minerals. The amygdaloidal cavities had been filled with secondary products, and the rocks had thus been considerably weathered before the intrusion of the granite, for the materials filling the vesicles partake in the general metamorphism. By the gradual increase of the brown mica and the production of a marked laminated structure indicated by the parallel disposition of the mica-flakes, these lavas and tuffs assume the aspect of true crystalline schists.<sup>23</sup>

Further north, in the southwestern counties of Scotland, several large masses of fine-grained granite rise through the Lower Silurian graywacke and shale, which, around the granite for a variable distance of a few hundred yards to nearly two miles, have undergone great alteration (see Fig. 282). These strata are ranged in steep anticlinal and synclinal folds which run across the south of Scotland in a general northeast and southwest direction. It is observable that this normal strike continues, with little modification, up to the granite, which thus has replaced an equivalent area of sedimentary rock (see p. 947). The coarser arenaceous beds, as they approach the granite, are changed into quartz-rock, the thin siliceous shales into Lydian-stone, the black anthracitic graptolite-shales into a compact mass charged with pyrites, and breaking into large rough blocks. Strata wherein felspar-grains abound have been altered to a greater distance than the more siliceous beds, and show a gradation through spotted schists, with an increasing development of mica and foliation, until along the edge of the granite they become true mica-schist and even a fine kind of gneiss.<sup>24</sup> The pebbly conglomerates which form a marked horizon among the unaltered rocks, are traceable in the

---

<sup>22</sup> J. C. Ward, *Q. Journ. Geol. Soc.* xxxii. 1876, p. 1. Compare the development of andalusite in regional metamorphism, p. 1040, note.

<sup>23</sup> Harker and Marr, *Q. J. Geol. Soc.* xlvii. 1891, p. 266.

<sup>24</sup> J. Horne, *Mem. Geol. Surv. Scotland, Explanation of Sheet 9*, p. 22. *Brit. Assoc.* 1892, p. 712. The microscopic structure of the altered rocks in this district has been studied by Prof. Bonney and Mr. Allport, *Proc. Roy. Soc.* xlv. 1889, and Miss M. J. Gardiner, *Q. J. Geol. Soc.* xlv. 1890, p. 569.