

First they assume a spotted appearance, owing to the development of small dark points and knots, which increase in size and number toward the granite, while the ground-mass remains unaltered (knotenschiefer, fruchtschiefer). The ground-mass of the slate then becomes lighter in color, harder, and more crystalline in appearance, while flakes of mica and quartz-grains make their appearance. The knots, now broken up, rather increase than diminish in size; the hardness of the rock rapidly increases, and the fissile structure becomes unrecognizable on a fresh fracture, though observable on a weathered surface. Still nearer the granite, the knot-like concretions disappear from the rock, which then has become an entirely crystalline mass, in which, with the lens, small flakes of mica and grains of quartz can be seen, and which under the microscope appears as a thoroughly crystalline aggregate of andalusite, quartz, and mica. The proportions of the ingredients vary, but the andalusite and quartz usually greatly preponderate (andalusite-schist). Chemical analysis shows that the unaltered clay-slate and the crystalline andalusite schist next the granite consist essentially of similar chemical materials, and that "probably the metamorphism has not taken place by the addition or subtraction of matter, but by another and still unknown process of molecular transposition."<sup>32</sup> In some cases, boric acid has been supplied to the schists at the contact.<sup>33</sup> Still more striking, perhaps, is the condition of the rocks at Rothau; they have become hornblendic, and their included corals have been replaced, without being distorted, by crystals of hornblende, garnet, and axinite.<sup>34</sup>

In the Christiania district of southern Norway, singularly clear illustrations of the metamorphism of sedimentary rocks round eruptive granite have long been known. Kjerulf has shown that each lithological zone of the Silurian formations, as it approaches the granite of that district, assumes its own distinctive kind of metamorphism. The limestones become marble, with crystals of tremolite and idocrase. The calcareous and marly shales are changed into hard, almost jaspery, shales or slates; the cement-stone nodules in the shales appear as masses of garnet; the sandy strata become hard siliceous schists (hällflinta, jasper, hornstone) or quartzite; the non-calcareous black clay-slates are

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<sup>32</sup> Unger, *op. cit.* p. 806.

<sup>33</sup> Rosenbusch, "Die Steigerschiefer," etc., p. 257.

<sup>34</sup> *Ann. des Mines*, 5me ser. xii. p. 318.