SOME REMARKABLE HOT SPRINGS AND ASSOCIATED MINERAL DEPOSITS IN COLUSA COUNTY, CALIFORNIA.

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A GROUP of remarkable mineral springs occurs in the valley of Sulphur Creek, Colusa County, on the eastern slope of the Coast Ranges. This section is formed of Cretaceous shales and sandstones, which to the west, in the higher portion of the range, are replaced by an older basement series.

The Coast Ranges, judged from the standpoint of their economic minerals, are characterized particularly by the presence of large deposits of cinnibar. A little to the west of the locality about to be described the cinnibar deposits are seen clearly to be closely related to volcanic phenomena. Mineral springs of every description are more abundant than in any other portion of California. Lava of late Tertiary age covers much of the country in the vicinity of Clear Lake and southward, and it is probable that the springs date from the close of the volcanic activities.

The famed Sulphur Bank at the eastern end of Clear Lake, where has been mined for many years both cinnibar and sulphur, is perhaps the best known of the interesting phenomena in this volcanic region. Almost unknown, however, is the group of remarkable hot springs and resultant deposits of gold and cinnabar in the Sulphur Creek Mining District. Here gold and cinnabar have been deposited from the same solfataric vent, but, what is the most remarkable, both in commercial quantities. While in most mineral regions, as far as our observations have gone, the deposition of minerals has almost if not quite ceased, here it is still going on, and the most excellent opportunities are presented for the study of such phenomena.

It must not be supposed that the gold deposits of Sulphur Creek are typical of the others of the State, for, indeed, they are not. This is the only locality, as far as I am aware, in which gold is found in veins in Cretaceous rocks in California. As a statement of general application it may be said that the epoch of the formation of quartz veins, and the associated gold deposits, ceased before the deposition of the lowest cretaceous beds; that is, following the great upheaval at the close of the Jurassic. Only locally is there apparent any metamorphism in the Cretaceous. The epoch of the cinnibar deposits is very much later, probably beginning at the close of the great volcanic activities following the Miocene, and in rare instances, as in the case under discussion, continuing up to the present time.

About the town of Sulpher Creek is a group of quicksilver mines, several of which show deposits of the usual character, that is, cinnibar distributed in irregular vein form in a gangue of silicified serpentine. The Manzanita mine lies on the north side of the creek, and it is here that the gold and cinnibar are associated in such an interesting manner. They occur in various places over a hill about half a mile in diameter, and which rises several hundred feet from the valley. It is evident that at some past time the whole hill has been thoroughly permeated by hot mineral waters, and either simultaneously or at different epochs, gold deposits were formed from silicious waters in certain spots, while in others cinnibar with more basic solutions almost changed the character of the original shales and sandstones. Cinnibar in small quantities, and often associated with sulphur, can be found over a large portion of the hill. The distinctly gold quartz veins occur on the western side, where great chambers have been excavated in following the veins. Here are thin seams of black quartz, with which calcite is often associated, frozen to the hard silicified walls (originally shale). It is apparent that the quartz was formed in open cavities, not only from the fact that it is always found firmly attached to the walls, but also that open spaces still remain through the centres of many of the veins. These spaces are lined with beautiful drusy crystals of quartz and are sometimes a foot across. The chambers have been worked out down to the water-line, where the gold was found to be largely contained in iron pyrites. In the outer portion of these quartz veins much bitumen is often found, while the centre is sometimes filled with soft white magnesian and aluminous material.

The Manzanita mine was first located for quicksilver but was subsequently worked for gold. In 1891 preparations were being made to save both the gold and the quicksilver, which in many places are found together. At the foot of the hill on the east, where the original works were located, a hot spring still exists. In one of the older workings near this spot beautiful examples of gold and cinnibar in the same hand specimen were obtained. The hot waters were finally encountered, and work in that direction had to cease. An examination of the whole hill shows a remarkable variation in the occurrence of gold and quicksilver with sulphur and bitumen.

The Monticeto mine lies on the south side of the creek just above the town. Gold has been found here in two sandstone strata a little distance apart and inclosed in shale. The sandstone stands vertical, while the gold occurs in thin horizontal seams of a loose sandy character. The adjoining shales are considerably silicified. The largest sandstone stratum has a width of ten feet and has been mined out for some distance on the ore shoot, which dips at an angle of 30°.

The most interesting of all the mines about Sulphur Creek is the Elgin, situated three miles up the valley from the village. Hot springs, still flowing a large amount of water and highly mineralized, issue from a very steep bluff on the south of the creek. Over much of an area, several hundred feet in extent, the formation consisting originally of argillaceous rocks and sandstone, and possibly some serpentine, has been almost completely replaced by silicious and calcareous sinter. The mine is opened by two tunnels, the lower one nearly four hundred feet above the base of the hill, and the upper less than a hundred feet higher up. The lower tunnel has been run in about one hundred and eighty feet with branches and cross-cuts. As one enters, heated air, saturated with moisture and sulphurous vapors, is at once encountered, and all surplus clothing is dispensed with. When well within the tunnel the air grows hotter and more stifling, but one is well repaid by the sights which open to his gaze, and by the feeling that he is witnessing nature at work in her laboratory in a manner which is seldom open to man. The hill seems to have been fissured in every direction. Through these fissures poured mineral waters, once much more abundant than at present, partly or completely filling the cavities and largely replacing their walls by silicious and calcareous deposits. The tunnel seems almost lined with beautifully banded aragonite mixed with silicious sinter of different kinds, varying in color from black to white, and in texture from porous to compact. Much of it is almost glassy and opalescent. Distinctly crystallized silica or quartz is rare. Here and there great cavities stretch away and downward farther than one can see, being completely lined with sparkling crystals of calcite, or stalictitic forms often grouped and branching like huge corals. One mass was observed nearly two feet in diameter, quite spherical, and entirely surrounded by radial stalactites four to five inches long. At the limit of one of the workings water of almost boiling

temperature was encountered. The heat and sulphurous vapors are almost stifling. Here it is that mineral deposition is still going on. Most noticeable is it in the case of sulphur, minute sparkling crystals of which line the cavities. Not only are cinnibar and sulphur present but gold also in small amount. In the lower tunnel a brown bitumen is abundant in the rock cavities. It results from the vaporization of bituminous matter in the deeper seated portions of these cretaceous rocks. The cinnibar for which the mine is being developed occurs impregnating the silicious sinter and aragonite, evidently having been formed with them. In exploring the deeper and hotter portions of this mine but little stretch of the imagination is needed to picture oneself within the very bowels of the earth.

In the upper tunnel is well illustrated the cooler conditions requisite for the deposition of sulphur. While in the lower tunnel it is found in comparatively small amount, in the upper the rock is richly impregnated with sulphur crystals. The cavities of the brecciated sinter fairly sparkle with them.

On the north extension of the Elgin, sulphur works have been opened for the mining of sulphur, which exists mixed with soft friable tufas of a variable appearance and composition.

A careful study of the Elgin mine would be a means of making one familiar with the formation of sulphur and cinnibar in the coast ranges. While the conditions are of course not all alike, the springs varying in temperature and composition, the manner of deposition is everywhere much the same for these minerals.

LETTERS TO THE EDITOR.

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The Data of Bird Flight.

IN *Science* for Jan. 26, 1894, p. 46, Mr. C. F. Amery, commenting on Professor Langley's recent "Internal Work of the Wind," makes inroads into what had seemed to be the fund of accepted observational data in regard to bird flight—soaring flight in particular. Possibly there is not to be found in print any deliberate and detailed summary of the bare, unexplained, facts of the bird's performance, upon which there is agreement among recent students of the subject, but a considerable list of accordant observations may readily be made up from the several notable papers of the last few years, which have dealt with the general problem from a new experimental point of view. The interested public is aware that the whole matter of air-navigation has of late been taken up *de novo*, by searching inductive methods, and it is fairly to be inferred that renewed observation of soaring birds, in connection therewith, has been more orderly and appreciative of essentials, hence more definite and trustworthy. It is, therefore, disconcerting to the non-specialist to find seemingly fundamental data of the investigation discredited.

Mr. Amery affirms, in effect, that the soaring bird cannot keep up to a level course in straight onward flight, whatever the motion, bodily or differential, of the air through which it passes; that it is by circling that altitude is maintained or gained. Yet it is a matter of frequent comment in regard to the sailing flight of certain sea birds, notably the "wandering" albatross, that they perform just this feat. Circling is the persistent habit of the soaring land birds, of which, among many competitors, the eastern vulture is perhaps past-master for varied skill; and there is conspicuous suggestion of a cause-and-effect relation in sustained circle-soaring. But the sea bird travels a wider field, and more commonly sails a straight course; moreover, its normal plane of flight is not at high altitudes, but within the possible vertical range of the sea-going observer, whose interest, furthermore, the bird reciprocates—in fact, if not in kind—so that its performance is brought into notice at short range. And the burden of testimony is that, in air conditions ranging between extremes of storm and calm, the albatross and other sea birds do, in fact, for long distances, travel the wind on undeviating courses, in virtually effortless flight. It has been my opinion that this paradoxical statement was yet a statement of fact, and that it was only the diverse explanations of this and other similarly puzzling phenomena that were in controversy.

For several years I have been an attentive observer of soaring birds, but my incentive has been limited to the interest of verification for myself of what were believed to be the accepted data of the modern investigation. Mr. Amery's dictum puts us (or at least myself) all the more into disorder because there is seemingly no recognition that, from such a postulate, we must undermine a body of doctrine.

If, perhaps, it is I, as a non-specialist in the audience, who am the one in fault, then there is compensation in the added value my verification-notes will have acquired, as contributions to a question still open. On that contingency I draw upon them here.

The best representatives of the air-sailers, among sea and land birds respectively, of which I have had opportunity for close observation, have been the remarkably tame gulls of San Francisco Bay, and the hawks of the Rocky Mountain region. The gulls are tamed by the ferry passengers, who feed them with crumbs, to be caught on the wing. They follow alongside, a little beyond arm's length. In a wind of moderate strength (I am not able to speak with certainty about directions) they will for some minutes maintain, without wing stroke, fixed positions, with reference to the boat, as steadily as though perched on the rail. In review of the lines of spectators, they abruptly drift forward and backward, and rise and sink between deck levels. As with flies in the air of a railroad car, the general forward course appears to be no matter of their concern. These subordinate motions are all in the vertical plane of the general forward motion—parallel to the boat's side, just beyond cane and umbrella reach. To the vertical plane, the line of the wings is held unvaryingly at right angles. Upon this steady horizontal axis there is, however, rotation at the shoulder; but barely perceptible in amount, and quick, with momentary pauses, discontinuous, and unrythmical—apparently an exceedingly alert and vigilant balancing process. The tail is slightly and slowly opened and closed, fanlike; and slightly, but quickly, tilted sideways, and up and down. The head is moved deliberately, in all directions, with the effect of a quiet glance, independent of the general nervous activity. At an increased distance, as with the leaning ship that has carried the roar of the wind in its sails beyond hearing, only the easy poise is noted. Occasionally a gull will venture to alight on the pilot house. He wheels into position, and, the feet hanging downward, connection is made through the last inch or two carefully, as in train-coupling with both sections in motion; but the wings remain fully extended until the body is at rest, when they are folded in gently, as though pains must be taken to avoid again catching the wind. If startled from his perch, he makes a strong wing stroke, and slants swiftly backward and downward; but the usual mode is a repetition, in reverse, of the alighting process: without the initial impulse of a stoop and spring, he floats outward and upward, ahead of the boat; then, perhaps, circles into place