

Bailey Willis Submits Field notes on Mt. Province and Abra

Read discerningly, these notes give many a clue to men asked to take a stake in northern mining ventures

"In view of the public interest in mining it appears desirable to state clearly that the object of our studies is not primarily to search for possible mineral districts. It is on the contrary to learn from the rocks and the features of the landscape the successive changes in form, extent, and character of the islands during geologic periods that cover the last twenty million years of their history. Under the action of forces which very slowly, but very surely lift mountain ranges, the foundations of the archipelago are dislocated and displaced. Volcanoes and earthquakes are incidental results. Air and water cause exposed rock masses to decay, forming soil, and rivers carve deep canyons in the rising ranges. He who knows rocks and who understands how they bend and fracture under enormous pressures may deduce from their present structure the nature of the forces that have acted on them. And this knowledge is important to the mining engineer whose ores occur in fissures opened during the movements of the mountains.

"As scientists geologists seek to discover the structure of the mountain ranges and to explain why they are mountain ranges. As mining engineers they may apply their knowledge of the structure to the systematic development of a mine.

"The Willis party is engaged in studying the structure and the later geologic history of the Philippine Archipelago. A better understanding of the forces that have created the islands may result from that study. And that knowledge may find application in the national development of mineral resources. We are not pioneers. A number of eminent Filipino, American, and European geologists have preceded us. We build on their work and hope to make some advance for the benefit of science and the Philippine Commonwealth.

"Our first problem has been to investigate the structure of the central mountain range that extends from Baguio to the northern coast and lies between the Cagayan and Abra valleys. Geologists recognize that it has been rising higher and higher above sea level during several million years and presumably is still being pushed up. During the uplifting the rivers have sunk their channels deeply, but they have not been able to keep pace with the elevation and consequently have steep gradients.

"Has the mountain range which is roughly 80 kms. across from East to West and 300 kms. long from South to North, been raised as a whole or has it broken into blocks. If the latter be true rocks in the larger zones of fracture should be extremely crushed, they would be easily washed away and a river would have grown along each zone of displacement or faulting.

"I thought it probable that the Agno Valley was eroded on such a fault zone and if so that the faulting might have some relation to the mineral deposits of the Benguet District. But examination of the valley shows that there is no major fault

zone on which it could have been sunk and the inference has been abandoned.

"A similar inference regarding a possible major fault extending north from Trinidad, between Tublay and Kapangan and along the eastern side of the range that is marked by Mts. Binnaca and Guirayan has proved unfounded.

"Further north examination of the country between Mts. Data, Bontoc, and Banaue has also failed to discover any evidence of great faults, such as might have developed in the central range.

"On the other hand there is evidence that the range has been arched up. Looking north from some high point that commands a distant sky line one may see smooth mountain crests extending in a flat curve. There are notches in the curve, often deep ones,—but they have been cut recently by rivers, and if we imagine them filled in we may restore an older surface, which was a continuous flat. It now appears arched, like the top of a loaf of bread. The curved surface is that which would be produced by squeezing the deep foundations of the range shortening the east-west width at the bottom while the uplift of the surface would result from the rise of the solid rock thus squeezed up. When compressed in this manner rocks shear into small blocks that slipped past one another in adjusting themselves to the general change of form. It is readily observed all along the mountain road that the rocks are thus broken up and have been squeezed past one another.

"We thus have good reason to conclude that the rise of the actual central mountain range is due to pressure from east and west in the foundations of the mountains; that an arched effect has resulted from the change of form, and that this occurred through intense internal shearing, instead of by faulting on a large scale.

"This conclusion has a bearing upon the probable continuity of mineralized veins. They are not likely to be wide or continuously aligned across the direction of pressure. They may be wider or more continuous if they lie across a direction of elongation. But whatever their orientation they are liable to end abruptly in the intricate maze of fractures in the crushed rock.

"On this examination of the central range of northern Luzon we turned to study the western flank, west of the Abra Valley. That valley has been described by Warren Smith in his pioneer work, as a fault valley. His observation was correct. It is defined by a fault, by a fault of the type known as an overthrust. The effect is easily observed. Coming from Bontoc to Cervantes, looking west, one is faced by the great height of Mt. Malaya (2352 meters) and other high peaks of the range west of the Abra River. Ravines in the face of the mountain are very shallow, they are very young, much younger than the valley of the Abra. Their youth

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The Author

Dr. Bailey Willis is a New Yorker by birth, eighty years old but preserving the mental and physical activity of youth. Columbia graduated him a mining engineer in 1878, since which time his career has carried him to distinction upon distinction, nationally and internationally, as geologist, seismologist, zoogeographer, etc., etc., until there is probably no greater living authority on such matters and related matters. Besides his home honors, France and Belgium have both decorated him for his scientific work; he belongs to many of the great scientific societies and associations within whose scope his work falls, and has been the president of the Geological Society of America, in London, the Royal Geographical Society, in Belgium, the Société Géologique de Belgique, and in America, aside from all the others, the American Philosophical Society, the American Academy of Arts and Sciences.

Dr. Willis lives at Palo Alto and is Professor Emeritus of Geology, Stanford, in general practice since 1922 as a geologist and mining engineer. His professional activity has taken him well around the world, as the list of his books, *Living Africa* among them, attests; also *Wao's Wao* notions of some of his outstanding work. We print Dr. Willis's field notes on his Mt. Province-Abra observations in hope they will be studied carefully. They are full of plain suggestions that should guide readers in their mining ventures. More recently Dr. Willis has been flying over the Buzayac and Mindwao with army air squadrons on maneuvers, and should he have anything to say on this region we hope to publish it. At Banaue, with us, another guest Dr. Foster Bain, technical adviser to Dr. Quirico Abadilla at the Bureau of Mines, Dr. Willis added informal comment to his field-notes findings—and no one dissented. He filed the *Journal's* March article on Mt. Province mining enough to forward a copy to Theodore Jesse Hoover, Stanford, dean of engineering emeritus.

main vein of the Macawili Mining Company, whose properties adjoin those of the Benguet-Itogon Goldfields group extends into the property. The General Management Company also advised of this possibility.

There are no so-called escrow shares set aside for claim owners. The company owns in its own right nine of the claims, and will be put to no expense in connection with the acquisition of the other 43 claims. There are 550 shares subscribed at no par value, while the sales value of the issue has been placed at ₱1,000 per share. The present subscribers will relinquish part of their shares to the claim owners for the 43 claims, and will also relinquish part of their shares to wipe out the ₱65,000 that has been spent in development thus far. The claims will be turned over to the company without charge, the idea behind all of this being to start the new company out as a going concern.

The Benguet-Itogon property has just been inspected by Robert Duce, geologist and mining engineer, a member of the staff of R. Y. Hanlon & Co. Mr. Duce is a University of Colorado man with ten years' field experience since graduation. He took samples during his inspection from Tunnel No. 3, one from the Valentin vein. The average value of the samples was ₱115 new valuation. He recommends driving on the Valentin vein at least to 200 feet in all, and stripping the ore to ascertain consistent assay values over this distance; and to raise on the vein in No. 3 tunnel with the same objective in mind.

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is due to the recent development of the mountain face, which has been pushed up several thousand feet. At the same time the whole mountain block has been tilted toward the west. The movement which can thus raise and tilt a mountain block is much like that of one hand over the other; the left hand, for instance, palm up and fingers slightly bent, the right hand laid on it palm down and pushed forward. The right hand is the mountain block, and the surface of contact of the two palms is the surface of the thrust or overthrust. But the Abra overthrust originates beneath the China Sea and the displacement of the upper block is an eastward movement of several kilometers at least.

"The Abra overthrust is a more superficial effect of the pressure that are squeezing the foundations of the central range.

"A series of three parallel overthrusts was observed in driving down the west coast between Tagudin and Bauang. They trend No. 20 to 30 degrees W. Each one defines a valley and lies along the northeastern base of a low range of hills. One runs from Balaan to Santol and beyond. Another of much greater extent passes near Bacnotan on the coast, past Disdis on the Naguilian road, underlies Mount Santo Tomas, and is identified below the Zigzag on the Kennon

Road in Bued canyon. It is a thrust of very considerable magnitude and is the cause of the dominant height of Mt. Santo Tomas, overlooking Baguio. A third, very minor thrust forms the valley between San Juan and Naguilian. This series is pushed up from the direction of west by south and appears to be independent of the east-west pressures farther north.

"It is desirable to note that the forces which thus appear to have affected the mountain region of northern Luzon are deduced from effects in the existing topography. The forces are now active and have been so during very recent

geologic periods. It is generally true that such forces have acted from time to time, with greater or less intensity and have produced similar results. Fissures appropriate for vein formations may thus have originated at any time in the past, may have been mineralized at any later time, and may have dislocated in any subsequent movement. This makes the task of the mining geologist, in trying to unravel the intricacies of vein structure, a very difficult one and taxes the skill of the most experienced.

"This progress report is written in the field, while the studies are in progress and is to be regarded as a preliminary account only."

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