

FRANCIS P. SHEPARD
AUTOBIOGRAPHY

Francis P. Shepard

August, 1980



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21-129

Autobiography Outline

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AN AUTOBIOGRAPHICAL SKETCH: INCLUDING THE TRIALS AND TRIBULATIONS
OF STARTING THE NEW MARINE BRANCH OF GEOLOGY

Francis P. Shepard

with contributions from
Elizabeth B. Shepard

Preface

Through one of the many strokes of good fortune that seem to have come my way during this life, I somehow blundered into a new field of geology which had previously been neglected. In my attempts to help in the development of this new field, now grown far beyond me, I have been constantly helped and encouraged by my wife Elizabeth, and in the course of various experiences which have come into our experience, I find that she has often been able to express them better in her letters than I have. Accordingly I am happy to include in these pages some of her accounts of these events in her words, showing far better than I might the human aspects of some of these experiences. I include also her account of her delightful childhood which, owing to the wonderful influences of her family, contribute so much to her character and, hence, have been so much a help to me.

Perhaps one should wait until the age of 90 before embarking on an autobiography, but how can we wait that long? Elizabeth and I have so many things we would like to share with friends about our happy life together and we feel that we can perhaps demonstrate to certain young people that it doesn't really require more than ordinary intelligence to succeed in life if you will throw enthusiasm into your work and have a real love for those with whom you associate.

Envy, hatred and jealousy are qualities that rob one of happiness. We may think we can say that we neither hate nor envy anyone. However, if I admire a pretty girl, even in my 80's, I still had better be careful.

When I speak of our happy life, and it certainly has been that in the 60 years we have had together, there were ups and downs aplenty, and still are, occasionally. It's funny how the slams in one's professional life mingle with the high points; the time I was notified that I was to be given the highest honor of English geology, the Wollaston medal was about the same time that I was informed that I had not been chosen as one of the many oceanographers who would represent the United States at the International Oceanographic Congress in Moscow, and a flock of my young colleagues had been so chosen. Another time I received news that a proposal for funds from the National Science Foundation had been turned down and got some very bad reviews, and then the next day I got a letter informing me that I had been chosen as the first recipient of the new Sorby medal from the International Association of Sedimentologists.

The strange thing about my buffets and the honors is that I really am convinced that I in no way deserved the honors, and that they usually came from work in a field in which I was not particularly good. On the other hand, I could never quite understand why I got my worst rebuffs for some writing that seemed to be among the best work I had ever done. Perhaps the answer to that problem is found in the biographies and autobiographies of others. This seems to have happened throughout the ages. I have certainly had more recognition than I ever anticipated and am most appreciative of it.

CHAPTER I: EARLY RECOLLECTIONS

In memory of Emily Blanchard Shepard, my wonderful aunt, from whose example I learned to love humanity and to hate no one.

My Childhood

My earliest recollections probably date back to the 19th century. In 1899 our new house was built at 89 Rawson Road, Brookline, Massachusetts and my father, never a man of caution, took my older sister and me for a walk across the beams built over the ample cellar, holding us each by the hand. We made our perilous crossing without mishap, but my mother would have had a fit if she had known. That reminds me of how a few years later, Father taught us to ride our bikes by putting us on the seat at the top of a hill and giving us a push. Of course we fell off and there was much crying, and little sympathy. This was in great contrast to the way ~~our beloved~~ Jenny, our ^{beloved} Irish nurse, coddled us and did everything but breathe for us. We adored her, and I know she made me into a prize sissy, quite unable to fend for myself with the little ruffians in grammar school.

I was just beginning to recover from some of this spoiling when I was taken out of public school and sent to a snobbish private school where the boys were mostly from a clique of rich Bostonians, and many were brought to school every morning by chauffeur. I was most unpopular, but fortunately soon began to grow tall and strong. Also, my athletic father decided I should learn to box and gave me some lessons. That may not have improved my popularity, but it did teach the boys a bit of respect for my fists.

I often wonder how I became such a puritan in my early days. I really believe that as a boy I never told a lie, and I never kissed a girl except for a cousin, or my sister with a peck on the cheek. My mother made me

take an oath not to look at any pictures showing nudity in females, and I think for quite a while I actually respected that oath. Which only added interest to pornographic pictures when I finally broke away.

I was brought up in a moderately wealthy family, but my sister and brother and I did not realize our wealth because our father preached economy to us constantly.

"Turn off that light! What extravagance! Get those shoes resoled! Take the streetcar; no sense in getting the chauffeur to drive you to school!"

Father bargained for everything and often went to the market to make sure we got the best prices. When the bills came in he inspected everything and accused Mother of being extravagant. One evening he had the chauffeur take Mother and himself to the theater and then he dismissed the chauffeur for the night saying, "We shall return by subway." Mother was determined to use a taxi, but Father would not have it and told her, "Take it yourself; I am going home by streetcar," and he did as he said. And she did as she wished.

When I was 14 the first great event in my life occurred. We left school before summer vacation began and sailed for Europe for a three-month tour. Going by way of the Azores, Madeira, Gibraltar, Algiers and Naples, everything made a tremendous impression on me, and I can still remember it vividly. After landing at Naples the trip became one of those horrible tours where you cover the entirety of Europe in a few months, staying only a few days everywhere. At my age then, it wasn't so bad, but this routine got a jolt while we were visiting the beautiful Dolomite Mountains at Cortina d'Ampezzo. I started up the trail with joy in my heart at making my first mountain climb,

running ahead only to catch my foot on a root and break my leg. It was probably good for the rest of the family as we had two weeks in the same place while I recovered enough to continue on crutches. My parents may not have realized how much happier it made the trip for them to have that restful period. Their main concern was that they had to cut out a few big and famous cities. I suffered little but it gave me a chance to do some thinking and to let the scenic beauty of the place sink in. The pattern of my travels in later life had its foundation right then. Whenever possible we have planned long stays at one or a few localities where we could get to know the country and the people and drink in the beauty of the scenery.

I should mention the effect that two people had on my early development. One was my Aunt Emily, Father's sister, with whom I lived when my sister had scarlet fever. In my family there was the usual amount of bickering, constant accusing each other of various shortcomings so it was quite a surprise for me to live for a time in a home where everything was kindness and politeness. If my aunt did not approve of something I did, she corrected me in such a gentle way that I was only too happy to correct my error and I basked in her warmth and love, very much like what Elizabeth and I have found among our friends in our half-time home now, on the island of Kauai. This gave me a glimpse of what a love of mankind could do.

The other influence came from a lady who was taking care of a friend of mine whom I visited as a teenager, Charles Hodges. She was caring for the Hodges children in their parents' absence. During the visit I was slightly hurt falling off a motor cycle and while I was recovering from my bruises she began to tell me about her sort of religious faith, in what was called "New Thought." She was convinced that if she believed firmly

enough she could cure anything. It sounded interesting, and although I did not become a complete convert, I did begin to use the power of thought to help my own ailments. I had been quite a hypochondriac, and my new philosophy certainly began to make a change in my well-being. It is, of course, similar to the philosophy of our broad-minded, modern doctors who often add to their advice to patients, to "Stop worrying." I suppose my good health through most of the years of my life has been considerably helped by this experience.

No one would have predicted that I would go into the academic field during my school days. I was really a very poor student. I almost flunked out of the private school, and was certainly at the bottom of my class for a while. Latin, which was needed at the time to get into the major eastern colleges, almost floored me. I had to work long hours every evening to get it. The only thing I really liked in prep school studies was government and economics of a sort taught by a very sarcastic teacher, Eugene Hecker, who loved to bait his aristocratic students with their staunch Republican backgrounds. He was the one who taught me to be a rebel against staid old ideas. I wonder how they ever kept him in such a stronghold of staunch old Bostonians who supported the school. The Lowells and Cabots were there in force. The old saying about Boston that 'The Lowells speak only to the Cabots and the Cabots only to God' had to be slightly modified by our particular Cabot since he spoke only about God; Goddamn and Jesus Christ and a long string of oaths in which God was frequently mentioned. With my puritanical ways, the foul language and questionable practices of my fellow schoolmates were somewhat horrifying. As I look back I guess I was the abnormal one of the bunch. So far as I know, my schoolmates have all turned out fine old Harvard graduates, except for the brightest boy in the

entire school who was something of a misfit and later became a wild-eyed radical, a real revolutionary.

How does a poor student get into the academic field? I really think the answer is quite simple. You find something that you are excited about and throw all your energy into it. My excitement in geology developed when I made a few mountain climbs and found my first true love. My father said, "It's just another craze; he'll soon get over it." It is strange that at school I had taken a course called 'Geology', before realizing that it had possibilities for mountain climbing, and I had made a barely passing grade. But now that I began to associate my love of the mountains with geology, I became intensely interested in the latter.

Elizabeth's Childhood [by Elizabeth B. Shepard]

I was born in 1895 in Milwaukee, a German community, the second of two girls in a family of strong loyalties, with enough means, but not too much. Following a beautiful, dynamic, glowing personality like my sister Gladys, I would have been completely overshadowed, had not my mother taught me to be myself and to emphasize my strong characteristics of determination, reliability, and ability to organize. Even in school I was expected to be like my sister. When entering Latin class my teacher asked if I was Gladys Buchner's sister, and "If so, take a front seat."

Gladys' sparks of joy overflowed even in class. One day in assembly she carried on a conversation with the teacher in charge by large cards held up and the teacher had trouble keeping a straight face. The teachers were so surprised to have me a good student after Gladys' average record that they built me up too much and gave me honors I'm sure weren't deserved.

Our home was modest but with much activity as my mother (like her famous forebear, Susan B. Anthony) was a great reformer and whatever

activities took her from her unwelcome domestic chores we were all called upon for assistance. She was horrified to have the garbage hauled through the city to the dump in open containers. By needling the right people in her quiet but persistent manner she got the containers covered; then turned to her next activity. She was very curious, and if something interested her, she pursued it and found the answer. She called the public library so often that they finally started a desk to answer telephone inquiries (this is still in operation, now a whole department). Later she started the 'Penny Lunch,' which fed a hot lunch to underprivileged school children and saved their pride by charging one cent, which certainly did not cover the cost, which was picked up by the school board. She was the treasurer and we had quantities of pennies to be counted and turned over to the educational department.

Another activity was working with a fine, and later famous judge in the juvenile probation department, a man by the name of Lindsay. Some of the delinquent children were paroled to my mother, and she guided and placed them in better surroundings -- often our own home. It embarrassed the rest of the family at first, but we soon learned to appreciate and love these underprivileged children. In fact, later in life when my lovely sister died at 30, leaving three children, it was Louisa, a former ward of the court, who greatly comforted my mother.

When he came home from work my father, a salesman in a hardware store, took over completely, enjoyed playing with us and our ever-present hordes of friends. If Mamma was busy with her outside activities he would cook and pick up the house, as my mother never put anything away. She was a fast worker but left a disaster like a cyclone in her wake so we

just naturally picked up after her. My father was of German descent, systematic, neat, and a great extrovert. Everbody old and young was his friend, and this last is the trait he passed on to me, for I love people. To me people are the most important thing in life. Papa, too, could fix things, and we had a wonderful swing and a playhouse made from two piano boxes used as a playhouse in summer, and in winter for a platform for sliding down on a sled.

Our family picnicked a great deal, either going by tandem bicycle with Gladys and me in baskets, or by taking the inter-urban streetcar to the end of the line. Later, in college, it was brought home to me how much this meant. A college friend whom I had visited in a hotel, which I found exciting, came to our home to visit and it was the picnicking she found most fascinating.

We always did things as a family; work, play, or reading Dickens aloud on winter evenings. I learned to love the woods and would gather wild flower plants. My mother in her wise way gave me my own little plot to plant and cultivate, and if I was neglectful in caring for my plants, she discouraged me from getting more until I tended the ones I already had. As my many interests developed she taught me to finish one thing before I started another, by answering my request for material for a new enterprise by expressing enthusiasm for the new project, but adding, "As soon as you finish what you are doing."

Each summer as soon as school was out, Mamma took us to Lancaster, Wisconsin (staying a week and then leaving us), where my grandparents, aunts and uncle lived. We went by train with a shoe-box lunch, changing trains in Madison to be greeted on the Lancaster train by the conductor, a great

friend of the family. Our arrival at Lancaster was always a so-called surprise, as we enjoyed the 'ohs' and ahs,' but our beds were always made up and our favorite meal ready for us. We took off our shoes and stockings and didn't put them on except for Sundays and our weekly visit to Granpa Buchner for dinner. He was a neat, strict person, but an understanding friend and we enjoyed him as he did us.

Grandmother Rhodes was a strong personality, practical and capable, which kept the family solvent. She read us a column in the weekly "Christian Herald" called 'The Doings of Gladys and Elizabeth,' and we discovered that some of our pranks we thought were unknown were not only noticed, but subject to hilarity. We supposed she was making believe to be reading these, and only when we were able to read did we find they actually were in print.

Grandfather Rhodes was an artist --- a silversmith from Cincinnati, and he was told to go west, and drink, to recover from tuberculosis. They went to Wisconsin, and he drank some, but not much. This was a blow to my grandmother; like her ancestor she was a pioneer in the Women's Christian Temperance Union (WCTU), wearing a little white enamel pin. They settled on a farm and Grandfather build with his own hands a lovely limestone house with a charming fan doorway. Grandpa brought two chests of tools; one to lend to friends, and his own precious one. They tilled the land and cut timber for extra cash. Grandmother started a school which was on a corner of their land, and the school teacher always lived with them. I still have the hand bell used to call children to classes in the one-room school.

We had an Uncle Howdie who owned the furniture store and was the town undertaker. He lived next door to my grandparents when they retired to

town from the farm. He and his wife Aunt Clara were childless, and they spoiled us and our wishes were always fulfilled. Uncle Howdie had the first car in Lancaster, a shiny red Ford with much brass which we helped to shine before we were given a ride.

Old Ned, the horse my mother had ridden to high school, was old enough to be safe for our learning to ride standing up on his broad back. As he went under the old crabapple tree, guided by whoever was not riding, the rider left Ned's back clutching an overhead branch, dangling until Ned was guided back under and the rider dropped on his back.

Being city girls we were leaders, and each summer our arrival was welcomed. We went on hikes and dammed a little stream so it was deep enough to show our friends that we could swim. We pinned our underwear between our legs and later smuggled the muddy improvised swimsuits to my grandmother who washed them before our spinster Aunt Linda, who was a music teacher, found out and was horrified. Playing hide and seek with our friends Gladys and I had the advantage as we were not afraid to hide in the hearse in the barn, for Uncle Howdie had showed us all the works.

Outside the immediate influence of my family, many friends enriched my life. One summer I accompanied an only child and her family to the north woods and learned to love the wilderness. Another summer I spent on the Fox River in a houseboat with my so-called "sin twister" and her affluent parents. Here I learned to appreciate my own family as the father of my chum was a difficult alcoholic and their home was not a happy, tranquil one.

My teachers also helped me to adjust to life as I was shy, and with their sympathy and understanding I learned to recite without fear. In my 6th grade I won the year-end prize -- a copy of Rebecca of Sunnybrook Farm -- as 'an enterprising student for outstanding improvement.' Also, my high

school teachers encouraged me and guided me to take the right courses so that I could enter Vassar. I never thought it would be financially possible, but they said, "Take the right courses anyway," and when the time came, I was prepared. I didn't know until later how it became possible. After I went off to Vassar and my sister to the University of Wisconsin, my mother rented our rooms and boarded two teachers for the school years, with the understanding that whenever we returned from college, our rooms were ours and they had to find other places to stay. I know it was a chore for my mother to cook a company meal every night, but she did enjoy the two teachers and I think it helped her not to be too lonesome for us. We were her life, and we heard later that when she put me on the train, she walked two and a half miles home instead of taking the streetcar.

Early Experiences with the Sea [back to FPS]

Since the sea later became such an important part of my life, it is perhaps worth considering my boyhood relations with it. My father's great joy, inherited from his ancestors, was his sailing, and understandably he was interested in having his children develop skills in handling sailboats. We were given a 17-footer in our early teens and with the occasional help of some slightly older neighbors, we used to sail it around the Marblehead Islands and enter in local races. None of us were really very good sailors but we learned the necessary rudiments and used to go with my parents on Father's larger yacht on some of his cruises, eventually including his annual Maine coast pilgrimage. My father thought motors an abomination and for many years did not have a motor installed in his yacht. The result was that we would get becalmed, often in a fog, and remain in the same

spot for hours. It did not arouse in me any particular love for the sea, and furthermore, I used to get seasick when it got rough, and that to me was an awful experience. I recall coming back from Europe in 1911 with a state-room well up in the bow of a small steamer with an awful pitch. I got so sick I swore I never would go to sea again as long as I lived. Fortunately I gradually outgrew the tendency as I matured and became moderately free from motion sickness.

Some of our yachting adventures in my boyhood days are perhaps worth including. One night near Rockland, Maine we were becalmed with no engine, as usual, and a 'pea soup' fog. Night descended and after rolling around for several hours we heard the fog horn of what we concluded was the Rockland-Boston Steamer. Of course, we had the right of way, but could they hear our little mouth-blown fog horn over their engine noises? They kept coming, right towards us so far as we could tell by the sound, and we were all ready to take to the small boats when suddenly the steamer loomed up out of the fog and immediately shifted its course just enough to flash by with all their brilliant lights and disappear again, leaving us in their wake in the darkness.

Another time we were sailing around Cape Cod, again in a thick fog but with some wind to give us steerage way. We heard a fog horn of a tug boat with its barges (one long and two short blasts). So far as we could tell, they were passing clear of us, but they were turning to go into Boston at the end of the Cape and we were continuing on to Marblehead, so our paths crossed. Suddenly dead ahead we saw a row of flashing lights, looking like a meteorite. It was the tow rope, a terrible thing for a small yacht to hit. "Jibe her to port," my father yelled, and fortunately the yacht had

sufficient way to make a quixk turn and we missed the cable by feet. Or maybe it was inches.

These were the days when radars were undreamed of wonders of the future, and the only fog horns for small sailing yachts were operated by lung power of the one blowing into a trumpet. Yet, despite all the new navigation aids available now, collisions still occur far too frequently.

On another occasion we were sailing across the Gulf of Maine at night, expecting to reach the Maine coast some time in the early morning. I was up in the bow as a lookout, as it was misty weather. Presently I detected some lights ahead and called the news back to my father at the wheel. He came forward saying, "You are always imagining you see lights." I asked, "Can't you see them?" "Maybe I can," he replied. "Let's describe them and see if we see the same thing." I could then see several more lights and I described them as accurately as I could and he agreed that they must be lights as he had picked out the same sequence. Just to make sure, we got another man to come up and see if he too could see them. He agreed. Since they seemed to be fixed, showing no red or green lights suggesting a ship, we decided they must be from the coast and that we were approaching Monhegan Island, though our dead reckoning did not agree at all with that possibility. We sailed on and the lights gradually faded so we thought it must be getting foggy, but there were no fog horns. On and on we sailed, getting more nervous about running into the island, although we heard no surf. Hours passed and finally dawn arrived and all we could see was ocean. How could we all have thought we saw the same lights? I guess it was imagination and the effect of suggestion from one sleepy observer acting on the imagination of another. Almost certainly no lights existed.

On two other occasions aboard my father's yacht I had experiences with natural phenomena which were unique and left a vivid impression on my youthful mind. One evening we were approaching Southwest Harbor on Mount Desert Island, Maine, when a curious type of lightening developed. It did not seem to have any thunder connected with it and we presently began to see what looked like balls of light moving along the rigging very slowly, and often at the end of its course it would flash like a sparkler. Later, describing this to a meteorologist I learned we had seen ball lightening. We were all completely mystified at the time. Looking at the rigging in the morning we could see no sign that the balls of light had done any burning or other damage.

I also remember one great display, observed along the Maine coast among the islands, of a meteorite. Suddenly a great flash of light illuminated the entire scene almost like daylight, and the great meteorite passed over us like a huge comet and then the light disappeared almost immediately. We never heard whether it was later found on land, but it very likely exploded and only small fragments came down which were not encountered. One can imagine what an effect that light would have on primitive people.

CHAPTER II: HARVARD COLLEGE AND WORLD WAR I INTERRUPTIONS

In memory of Professor Wallace W. Atwood who inspired his students with his remarkable two-handed sketches drawn on the board during lectures.

One is supposed to get a liberal education before receiving a degree from a reputable college like Harvard. I certainly did not. I got my bachelor's degree with a study major in geology but with only a little smattering of liberal arts. I suppose the blame for this failure falls partly on World War I which the United States entered during my freshman year. Harvard was extremely lax in those days, war or no war. All the time I spent there was from September to late April the first year, when I was given credit for the last six weeks for going full-time into the Harvard ROTC -- after we became involved in the war. Coming back from summer training camp in September, I continued my school work until late March of my sophomore year, but again was given credit for my courses when I enlisted in the Naval Reserve. Getting out of the Navy in December 1918, I took a two-quarter speed-up course from January to June and was so near to having all the course points necessary to get a degree that I was able to get the rest by going on a summer geology field trip to the Rocky Mountains with Professor J. B. Woodworth; then doing a thesis study for the remainder of the summer under Professor Wallace Atwood. Presto change! I was a full-fledged Bachelor of Arts after about two and a half years at my Alma Mater. How does a person get educated in that short time unless he is a genius? And I was far from that.

I might confess why I went into the Navy. The summer ROTC was a demonstration of what an awful soldier I would make. As my company captain said, "Well, he was the worst private in the company; always out of step, but at least he tried." All the marching gave me a continuous round of

blisters, and I was in constant agony. I decided that even seasickness would be preferable to that. Seasickness: In my Navy tour I never did get to sea except in a rowboat on the Charles River. I did at least learn the principles of seamanship and got high marks in that, getting into the cadet school at Harvard for a four-month course that again obtained for me a diploma and an ensign uniform like that of the four-year course at Annapolis; but what a major contrast in what we learned in that short period compared to four years at Annapolis. The cadet school episode was a long hot summer of studying hard and drilling with light artillery and small boats, while principally learning navigation and principles of seamanship. Our commanding officer, a reserve captain, was a martinet who was thoroughly disliked. I remember him^s telling us that as cadets we were now considered gentlemen and should be an example to ordinary seamen. He told us he had recently been to Nantasket Beach and was horrified to see a cadet lying on the beach with his arm around a girl. "Not the thing a gentleman should do."

A few weeks later an event occurred that delighted us all. Our dormitory in Harvard's Holyoke Hall was right across Massachusetts Avenue from the office building where the captain had his headquarters. One night the watch in the dormitory looked across the avenue and was amazed to see the lights come on in one office, and there was the captain and one of the pretty secretaries. More and more cadets crowded to the front windows to watch the couple, oblivious to the dormitory across the street, as they proceeded to go a lot further than that cadet on the beach at Nantasket. By morning everyone was talking about the incident and the staff was forced to take action. Our unpopular captain was transferred and we got a new one who was much more to our liking. Life became more bearable until near the

end of the four-month period when we were suddenly confronted with the influenza epidemic that began in September of 1918. Then all sorts of foolish moves were made; for instance, we were called out in the middle of a cool night to stand barefoot in the halls for a period of time, after which we were each asked if we had any cold symptoms. Most everyone did by the next morning. Another time, when a rain started as we were making our usual run around the Harvard Yard in close order formation, we were ordered to return to quarters and put on our leggings which we did, over wet feet, and continued to run. More trouble. People began dropping out, and reports of deaths began coming in; it was pretty hectic for the last ten days or so before we finally graduated.

Luckily for me, the war ended soon afterward and my name being near the end of the alphabet, I was never called up. In those cost-plus construction days no job was found for any officer with a name beyond the M's. Ship construction was slow, due to cost-plus contracts and war profiteering. So I got out with only a glorious victory parade through the streets of Boston, with drawn sword in front of a company of 300 'Yo girls' (Navy secretaries). I was soon back in my college work, taking all the courses allowed, heading toward that undeserved degree.

The preceding gives only one aspect of Harvard, with reference to a difficult and unusual period when war dominated the situation. Actually, I have grown through the years to appreciate what a really remarkable university Harvard is, and even what it was at the time I attended. It has not only maintained what is probably the most outstanding faculty in the nation, both in science and the arts, but it has developed one of the very best schools from the point of view of education of students. Even

for students entering as I did in 1916, the freshmen dormitories located down along the Charles River, a few blocks from the Harvard Yard, were a fine introduction to college life. The many faculty residents gave us inspiration and took a great interest in the students, producing an outstanding scholastic feeling. The Harvard rule preventing students from joining any clubs or fraternities during their freshman year was a particularly good thing, so that they mostly ate together in their dormitories and a mixing of all classes of society was achieved. Almost all of the social activities were in the form of clubs open to sophomores and upperclassmen. A very few fraternities existed, but not of the exclusive type found in many colleges, and they actually changed to clubs in 1920. I happened to join Alpha Sigma Phi, a fraternity which was a source of delight to me as I formed many good friendships there in spite of my short period of attendance. We ate meals at the fraternity house, but all slept in college dormitories in the Harvard Yard, so we were given the chance to associate with many other students besides our own particular club or fraternity.

Despite my concentrated courses which did make studying a little harder than for students taking a normal load, I had time left over for exercising and I played a good deal of tennis, among other games. I don't think I was what was known as a 'greasy grind.' Life was really very pleasant and I am only sorry I did not continue longer with my studies so as to get a better education.

I do think Harvard was rather inclined to overlook teaching ability in some members of the faculty who showed great promise in research. For example, we had a professor of mathematics who was said to be one of the

greatest mathematicians in the world, but he would come to class sometimes so unprepared that one of the brighter students would have to help him solve a problem. I wonder if such a thing would be possible today at Harvard. I doubt it. A more pleasant recollection is the lectures given us by Professor Wallace Attwood in 'Physiography.' This genial professor could draw with both hands on the blackboard and produce beautiful illustrations for us of the physical features of Earth relief, which he was discussing. These sketches made a deep impression on all of his students.

CHAPTER III: MATRIMONY; CHICAGO UNIVERSITY AND A THESIS FIELD SEASON
AND HONEYMOON COMBINED IN THE CANADIAN ROCKIES

In memory of Professor Rollin D. Salisbury whose teaching methods insured that all Geology students from Chicago University were well grounded in the basics of that science.

Interest in Matrimony

My rather sudden interest in matrimony was, I suppose, one of the results of getting into the military service, and following the general trend of the times. I had known Elizabeth Buchner for over a year because she had come home from Vassar with my older sister Katherine, for their vacation, while I was a freshman at Harvard. We had become good friends when I later visited Vassar and we had taken a long walk together. It was not, however, until I became immersed in the Navy training camps that I suddenly began to realize that this was the girl for me, and began to make attempts to see more of her.

At the beginning of my short Naval Reserve career, when I was a second-class seaman, I got into trouble with one of the petty officers in training camp and was denied a weekend pass that would allow me to go and see Elizabeth at Vassar. I was greatly disappointed, but one of the other seamen in camp said, "I'll answer for your name at roll call, so you just go anyway. No one will know the difference." He did, and I did, and Elizabeth and I had a wonderful weekend, falling deeply in love. It seems funny thinking of it nowadays, but all we did during that Vassar visit was to take a long hike up a mountain, holding hands. But things were different then, and we were the innocent of the innocent. During the hike we ate at the Mohawk mountain-top hotel and I paid the bill, which took almost all of the money I had. As a result my sister and Elizabeth went around their dormitory borrowing money from their friends so I would have enough to pay my fare back to Boston on the night train.

A month later, before going to the Harvard Cadet School, I had a couple of days vacation at home. Still in my sailor suit I was overjoyed when my sister returned from Vassar at the end of the term, bringing with her a most welcome visitor, Elizabeth. It seemed the right time to declare myself, and since the family all left us to ourselves early in the evening, why wait? I timidly asked her if she could ever care for me, and getting a quick nod, I broke my long fast and got my first real kiss. We soon went up to tell Katherine, waking her from a sound sleep. She said, "I don't believe it. I have not even got engaged to Ralph yet." She soon did.

The next day we got our photographs taken (insert photo), and some 52 years later, for our 50th wedding anniversary on the same date, the 12th of June, one of the photographs was resurrected by our younger son Tim, and blown up to life size and exhibited at the entrance of the house where they had a champagne picnic party for us.

I did not have any feelings about extrasensory perception until a few weeks after we had become engaged. I was at the Harvard Cadet School and we had knocked off drills and classes at 5:00 one afternoon and I was taking a leisurely walk around the Harvard Yard when suddenly I had an awful feeling as though something bad was happening to Elizabeth. I was literally terrified and did something I have never done before or since. I went to a telegraph office (phoning was not done much in those days), and sent Elizabeth a message asking if she was okay. I got a reply that she was, but that a letter would follow. When it came, it said that the same afternoon at which was apparently the time of my fright (correcting for time zones in the Middle West) she had been out in a canoe on a lake near Oshkosh when a sudden thunder storm had come up and the ^acanoe tipped over. She and a

companion clung to the side of the canoe and finally managed to push it safely ashore. I don't know what things like that mean, but it is pretty hard for me to believe that they are simply coincidence.

First Year at Chicago University

After completing my January-to-June session at Harvard and taking the summer field trips that gave me my Harvard degree, I continued my studies of geology at Chicago University. This choice for graduate work was admittedly very much because my fiancée lived in Milwaukee and was working there for Cutler-Hammer after her graduation from Vassar. Thus I could get up to see her every weekend and stay with the hospitable Buchners. However, I was also impressed with the geology department at Chicago which was well recommended by our old family friend, Professor Wallace Atwood who had been at Chicago before coming to Harvard. Since Atwood would have been one of my chief reasons for staying at Harvard, and he was about to become president of Clark University, the move seemed particularly advisable.

I have quite mixed feelings about the three years I spent at the University of Chicago, from 1919 to 1922. There is no doubt but what all of us students received a thorough grounding in basic geology. You could not take Professor R. D. Salisbury's courses without having a good grasp of everything in the voluminous Chamberlin and Salisbury 3-volume textbooks. Come unprepared and old 'Sal' would fire questions at you 'til you were covered with perspiration, and you would never come unprepared again. What a teacher! Professor J. Harlan Bretz followed in Salisbury's footsteps and gave his students a particularly fine training in field work. He also became world famous for his discovery of the Spokane Flood which was a truly

spectacular event in the history of geology. The kindly Stuart Weller was a real inspiration to the paleontologists. The students were hard-working, not of the type who try to get away with an easy life, such as one often finds nowadays in many graduate schools.

There was one serious drawback for geologists studying at Chicago. T. C. Chamberlin, one of the early great geologists, had just retired when I arrived. He had been such a dominant figure and had so many ideas which he promoted with such really religious fervor that his students and colleagues were, for the most part, convinced that he had solved the main problems of geology and they took his ideas almost as if they were a religion. I remember thinking, "It's too bad I entered the field after most of the important problems have been solved."

I found the students in geology very friendly, although social life was restricted by the necessity of hard studying. I used to study all the way up to Milwaukee on the Northshore Electric and all the way back so that my weekends did not seriously interfere with my courses.

Very shortly I was invited to join the graduate scientific fraternity, Gamma Alpha, which included what appeared to be the pick of the scientific graduate students at Chicago University. We ate there and slept in a large dormitory on the top floor of the house. I did find that bed bugs, remnants of the World Fair of 1895, still existed despite several fumigations of the house. I seemed to be very prone to attract them. Further fumigation finally settled that problem. I was glad to get to know scientists from various other fields than geology, and enjoyed living with that group immensely.

I became quite well acquainted with Rollin Chamberlin, the son of the famous T. C. Chamberlin, who was teaching structural geology at Chicago

University. He was a wonderful mountain climber and very much interested in mountain structures. We discussed at great length possible problems for my doctoral thesis and finally decided that one very fascinating subject was a great intermontane valley called the Rocky Mountain Trench, that extends from the U.S.-Canadian border in a northwesterly direction between the Canadian Rockies on the east and a whole series of mountain ranges on the west. This great intermontane valley is the birthplace of the Columbia River and contained further north the Canoe, Fraser and Crooked Rivers, fed in turn by the smaller Rock, Fox and Kicheka Rivers. The name "Crooked" must have been given to the river when it was not following the straight Rocky Mountain Trench. The origin of such a great valley was of course a mystery and it seemed like a most interesting feature to investigate to see if it had indications of some great structure which could account for its length and its remarkable persistence as well as its relatively flat floor with few interruptions. It was perhaps too great a problem for one just starting in the field, and in view of what we now know about world structures, would seem to have been virtually impossible for one graduate student to solve. However, it was a great challenge. I decided to work in the area during the summer of 1920 and combine it with our honeymoon.

Our Honeymoon in the Rocky Mountain Trench [by Elizabeth]

My life of adventure began when I married a geology graduate student. I was fresh from two years of doing research in physics for a commercial firm. Our marriage started by combining work on Fran's doctoral thesis with a honeymoon in the Rocky Mountains. In preparation for three months of camping in a pup tent I read books on camp cooking, even making out menus

for meals. To my amusement, once our camping started I found this preparation was useless as most of the items in my menus were not available at the stores, when there was a store, in this great intermontane valley where we were working.

We started at Gateway, Montana on the border between the United States and Canada, and not having a car, we moved by train; one baggage car and a caboose with room for a few passengers, called the Kootenay Central. The train ran north in the valley twice a week and returned south on alternate days. With a rough map we planned to stop at each station and do the local geology. A few days later, getting on the next northbound train we would move to a new locality. Some of our stops had stations; others had only a platform, and some had nothing at all; just a name on the railroad map. We made them all, taking my wardrobe trunk, full of trousseau, off at each station to sit unopened. I did not open it once during that summer, so my trousseau rested while our camp clothes and supplies were handled in two large duffle bags. Our transportation to a suitable place to put up our pup tent varied from a local rancher's car to a horse, a wheelbarrow, or even a backpack.

At some of the stations we were met by inhabitants who had heard of our slow migration along the valley, and greeted and adopted us with rival sites suggested for our camp. If for some reason we were not at the station when the train came in the combined conductor-baggage man would wait for us, as the schedule was flexible.

Our friendly neighbors soon saw what greenhorns we were and taught us to make bannock bread in a homemade reflector oven, and coffee in an open pot instead of a percolator. Using the cold mountain stream for our

refrigerator once proved disastrous when a friendly brown bear invaded our camp while we were geologizing, causing great havoc with what he could not eat. So we learned to keep our supplies hanging from a tree branch with a damp burlap cover to keep them cool. Our meat market was usually a local rancher who had slaughtered recently and the price of all cuts was the same: 25 cents a pound. We soon learned the most tender cuts and the easiest to prepare. Once we bought a chicken as a great treat, but were amazed to get it alive from the farmer. To hide our ignorance we took it back to our camp. I held the chicken while Fran yielded the axe to decapitate it, but the axe came too close to my hands and I let the bird go. We had a wild chase through the bush to recapture it. This time Fran wrung its neck and, not knowing how to remove the feathers, we skinned it and popped it still warm into the frying pan. What a tough meal we had! Later we learned to clean and prepare various fowl, both cultivated and wild, and once even felled a fool hen (local grouse) with a rock.

At one stop we found a ready-made campsite all cleared, with even tent poles cut. We pitched our tent and set off to do the geological work. On our return from a long day of climbing and mapping we found our tent surrounded by Indian tepees. Somewhat dismayed, we prepared our meal and ate it, watched the whole time by inquisitive Indians peering at us through the brush, not seeming to know we could see them. Later we were made welcome like honored guests and they were greatly amused by our equipment and by Fran's cooperation in work around the camp. Explanation of what we were doing there was past their comprehension. Who needed to know more of their country than they already did?

After a month of geologizing we came to a small resort on Lake Windemere where we took a few days' vacation: mountain climbing, sleeping in a real bed, and eating civilized meals that we didn't have to prepare ourselves. Then six more weeks of work, and we reached Golden, the northernmost terminal of the Kootenay Central and the juncture with the main line of the Canadian Pacific. Here we celebrated by reading our first mail, including descriptions of sophisticated wedding presents received after we had left Milwaukee; and we each ate three banana splits.

I learned to walk a trestle over the Kicking Horse River, and we continued to work in spite of clouds of mosquitoes -- they obscured the sun. We wore puttees and mosquito helmets, and we carried switches in each hand. We later learned that the railroad camp had been closed because of the mosquitoes.

Camping at Glacier, British Columbia near a hotel where we ate dinner, we found the bears were again too friendly. One morning I awoke to see one at my knees looking into our tent. He was more surprised than I was and scampered away. However, he returned while we were away from camp having dinner at the hotel. He tore down the tent and rummaged through all the 'grub', leaving a mixture of oatmeal, prunes and eggs all scrambled together.

We took another vacation at Lake Louise, the hotel beautifully located on a lake encircled by mountains, most of which we climbed. Mount Temple was the highest mountain in the area; a slow, steady ascent to 11,600 feet. We left the Valley of Ten Peaks at three in the morning and reached the summit at noon. Being my first ascent of a real mountain, I learned not to drink water en route, and to keep a slow, even pace like Fran and our Swiss guide, Walter. The elation of reaching the top and enjoying the sweeping

panorama laid out like an aerial map below us was a new experience for me. Our next ascent, Mt. White, was quite different -- not so high, but this climb included rock work; traversing a ridge with a thousand-foot drop on either side. I learned the technique of rope climbing, being placed in the middle between Fran and our guide, never to drag the rope on the ground, and to hold an extra loop, and to move only when directed.

Each evening we would rendezvous with other climbers at the hut of the Swiss guides to narrate our daily experiences. Through these meetings we found that it was possible to traverse along the lake and climb the Victoria Glacier up to Abbotts Pass and down the other side to Lake O'Hara; then over another smaller pass to the Valley of the Ten Peaks. With our guide Walter, and supplies for two days, we took the easy walk along the lake to the foot of Victoria Glacier. Before this, during our days of relative leisure at the Chateau Lake Louise we had seen and heard avalanches as the sun hit the glacier hanging above the approach to the pass. When we started up the glacier we roped and slowly worked our way around crevasses, hoping we were early enough to miss any avalanches. I wanted to stop and drink in the beauty but was kept on the move by our guide. We suddenly heard a roar like an approaching train and looked up to see a fall of ice as large as Niagara Falls directly above us. We ran as fast as we could, with me still in the middle position on the rope, until we reached a crevasse too wide to cross. There we threw ourselves down on the ice, covering our heads with our rucksacks. The roar continued and a whirlwind of ice fragments swept past us. The blast continued as other smaller falls developed. When it finally stopped and we had caught our breath, we surveyed our surroundings to find we were in a field of broken ice fragments. As soon as my knees returned

from jelly to normal, we continued up the glacier to Abbotts Pass (named for a man who lost his life at that spot). From the pass we looked down the other side and spotted the cabin in the woods where we were to spend the night. It seemed simple to walk directly to the cabin, but due to some necessary detours we had trouble locating it. When we did, we found it was not luxurious, but it was shelter and after a simple camp meal we slept like logs on our pine bough beds, still wearing our clothes for warmth. Next morning we rose early, and after a good breakfast, started our slow but easy climb over a couple of low passes and down to the Valley of the Ten Peaks before nightfall. On our return to Lake Louise we recounted our tale to the other climbers in the guide hut.

Continued Study at Chicago University [back to FPS]

Returning from our Canadian Rockies honeymoon, we were immediately faced with the problem of finding a place to live that was within our means. Everything seemed to be so expensive that we decided first on some house-keeping rooms with kitchen and bath privileges. It was fairly near the university. However, the first night we found that the place was not only overrun with cockroaches, but I woke up to find myself badly bitten by bedbugs; Elizabeth fortunately seemed to be immune to them. We could, I suppose, have put up with the arrangement, but we decided to make one more desperate look, and to our great joy we found a lady who wanted to sublet her one-room apartment, which was new and clean, at a price we could just barely afford if we economized on everything else. It was a long walk to the geology building but we were both good hikers and used to make the walk together with great regularity, going by way of Jackson and Midway Parks.

Elizabeth took a good deal of interest in my work and used to type-write for me, and even do some drafting of diagrams that developed as my thesis began to take shape. Also, having roamed freely in the library stacks at Vassar, she convinced the authorities to break their rule about use of the closed stacks in our geology library, and she was able to catalogue and index articles which she thought would be of interest to me in my work on structural geology. She was a great help to me, much more than many of the other wives of graduate students who mostly proceeded to get pregnant.

Fortunately we had been given some instruction on family planning, which was not too well known at that time by young married couples. We often spent weekends in Milwaukee getting our laundry done and eating delicious home-cooked meals, enjoying family and friends. Thus our two years during which I was a graduate student went very pleasantly. We did most things together and we returned again to the Rocky Mountain Trench the second summer to finish my thesis investigations, turning down a free trip to Europe which my parents offered us.

Our second summer in the Rocky Mountain Trench did not include any honeymoon holidays, and we were considerably restricted in expenses. We did very little mountain climbing, except as was absolutely necessary to obtain information for my thesis. We had a better tent and were much better acquainted with the art of camping, so we enjoyed our summer in the open and I returned with all sorts of ideas as to the geology of the area. I began to think the Rocky Mountain Trench was anything but the graben which my former Harvard professor, R. A. Daly, had suggested of its southern end some years previously. In fact, I took considerable pleasure in reporting that the supposed normal fault at the southern end which Daly

described, was in reality a thrust fault and that I had discovered evidence that, instead of being a graben, which would have shown younger formations in the outcrops in the central portion of the valley in one central row of hills, the rocks were actually older, making it just the opposite of a graben. None of my discoveries, however, seem to throw light on the explanation for the great length of this intermontane valley.

During my last year at Chicago I began, with the help of Elizabeth, to browse deeply into the literature on mountain building which was well represented in the large geology library at Chicago University. I soon was forced to abandon my earlier feeling that geology was largely a worked-out science because of such great men as T. C. Chamberlin, who I had been told had solved most of the problems. I found, instead, that there was little agreement among the authorities and that the origin of such mountain structures as those of the Alps was a wide open field for speculation. I even discovered that many well-known European geologists were advocating that the Chicago group, in effect, believed in wild nonsense; for example, that continents were drifting and oceans widening, and that mountains and plains were balanced against each other in what was called isostasy.

I became a rebel, very much like a devotedly religious student who finds that his fundamental beliefs are contrary to the facts of a growing science, so that he tends to distrust all of his early training. We had been trained to have a sort of religious faith in Chamberlin's ideas, and his students had a great feeling of loyalty to the old master, much of it deserved.

Now I was prepared to challenge many of Chamberlin's ideas, and was actually ready to bring forth my arguments in my doctoral examination. As

fate would have it, nobody asked me any oral questions that allowed me to present these radical ideas. I can well imagine what would have happened to me if they had. After all, they were trained in the defense of Chamberlin hypotheses and I was just a beginner with no experience in presenting arguments. I would probably have been torn limb from limb and told that I was in no way ready to receive a doctoral degree. In one respect they would have been right. Not perhaps because of my radical ideas, many of which are now standard doctrine in geology, but rather because I was not properly prepared in physics, chemistry and mathematics. Little attention was paid to the courses I had taken in these subjects and I had neglected them badly, concentrating on geology, a short-sighted program that has been a handicap to me in all my future career.

I should say in closing this discussion of the University of Chicago Geology Department that they subsequently showed a remarkable amount of fairness in allowing people like myself to publish in their departmental controlled Journal of Geology articles which were radically opposed to some of the Chamberlin hypotheses.

Post Ph.D. Attempts to Solve Problems of Crustal Deformation

I completed my doctoral studies with the feeling that I was sort of preordained to rescue the science of geology from the lethargy into which it had sunk, particularly after the long years of domination by such authorities as T. C. Chamberlin. I was bursting with ideas and began writing them on cards and classifying them. I even kept a stack next to my bed and would wake up with thoughts which I wrote down before they could be forgotten. After classifying these ideas I began to write articles and soon was getting these into the shape of papers which were submitted to various journals.

Some of them were rejected, but others were accepted, even by the Journal of Geology, where my old professors served also as editors and were often horrified by my questioning of the Chamberlin doctrine. However, one must give them credit for accepting the articles anyway.

As I look back on this period I realize that I was in too much of a hurry to get these somewhat original ideas out, and did not document them sufficiently to make them convincing. One article entitled "To question the theory of periodic diastrophism," was perhaps worth publishing as it pointed out some serious weakness of the Chamberlin idea that mountain building occurred mostly in concentrated form at the end of geological periods and eras with long periods of quiet in between. My paper did get strong support from a presidential address of the Geological Society of America a few years later. However, this paper of mine should have been supported by much more data to have been truly valuable. I was in too much of a hurry. One of the senior professors at the University of Illinois gave me a serious talking to about what I was doing and convinced me to change my tactics before I got the reputation of being superficial. This talk started me on an entirely new course. I began gathering great quantities of data and have followed this practice for most of the rest of my career, with particular emphasis on studying the phenomenon under discussion in as many areas as I could possibly investigate to see if I was describing only a local effect or a world-wide effect. This has paid large dividends. I do still find scientists who criticize this method; notably that group who call themselves physical oceanographers and seem to be confused by having too much data.

CHAPTER IV: EXPERIENCES ON FACULTY OF UNIVERSITY OF ILLINOIS

In memory of Professor William Oldfather whose Saturday afternoon hikes for University of Illinois faculty provided a year-around healthful form of exercise for young and old, but also a liberal education in a variety of subjects, particularly world affairs.

When I started my teaching career as an instructor in the geology department at the University of Illinois in the fall of 1922, I was well prepared for teaching elementary courses in the subject, but was not prepared to deal with the type of students who took my courses. In those days the university was accepting any student who had a certificate from an Illinois high school. This often meant that they had spent four years in attendance and had not done poor enough work that their teachers saw any good reason to get into the bad graces of their parents by failing them. Also, in many cases they must have wanted to get rid of them, as keeping them in high school for an extra year would serve only to demoralize the better students.

It was a shock to many of these young people to find they were enrolled in sections of elementary geology in which the instructor expected them to come to class prepared to discuss assignments or even to take short unannounced tests. Other instructors of the elementary course sections did not require such preparation and merely required the students to take mid-term and term examinations which were not difficult to pass with just a little study before the announced examination dates.

As a result of my rather high standards I began to find that my sections of the elementary course were being avoided and it began to look as though I might presently find I had so few students that the dean would begin to wonder if I should be kept on the payroll. However, I did attract some of the better students and soon I began to make my sections more interesting by introducing large numbers of slides on a daylight screen. The use of

many specimens of fossils, minerals, etc., also gave the sections some special interest. I did relax a bit on my standards, realizing that ordinary high school graduates were distinctly less prepared than the selected students who were admitted to such schools as Harvard and the University of Chicago, and I was forced to grade with less severity. Furthermore, I think some of my colleagues realized that they were perhaps somewhat lax in their methods and began to have somewhat higher standards. Geology began to lose its reputation as a snap course. In any case, I did not get fired because of failure to attract students. In fact, I began to become moderately well-liked as a teacher and was soon given more interesting classes to teach, with rather substantial numbers of enrollments.

I still have occasional visits from these old students and I am pleased to find they still remember those courses I gave half a century or more in the past. I guess what they liked most was my enthusiasm. I really did not spend much time preparing courses because I was always more interested in my research, but I managed to throw some of this interest into my teaching and I guess that made up for other deficiencies.

I Enroll Illinois' Greatest Football Hero -- 'Red' Grange

In 1924, as a young instructor at Illinois University I had the amazing experience, in view of my reputation, of finding in my section on elementary geology, a football hero. I was not much of a sports spectator, though I had played on my prep school football team. However, one of my friends said I really should go and see this student of mine play in the forthcoming game against Michigan. That game made sports history. If my memory is correct, Red made four touchdowns in 7 minutes of play. For those 7 minutes

it was thrilling to see his running, but the coach pulled him out of the game after that; defensive action was ordered for the rest of the long game, and I found I was actually getting bored as the game dragged on to an end. The following Monday when our hero came into class late, looking tired, the students cheered him. It wasn't easy to get them involved again in the geology problems we had been discussing.

Shortly afterward some of the boys at his fraternity invited Elizabeth and me over to dinner and we had a good talk with him. He still seemed to be a nice boy from the farm who had landed in the midst of a whirlwind of hero worshipers, and he was a bit confused. He told us how hard the coach made them train in football practice, so they were physically exhausted, and studying was almost impossible. We could see what it was doing to him -- the combination of hero worship and the grueling football practices. Rather than envy we felt deeply sympathetic toward him.

From that time on I decided that watching sports was for the birds. I have never watched any more games, seen any races, or viewed any contests on television. If a person is healthy, why would you want to watch others exercise? Do it yourself! Furthermore, I have come more and more of the opinion that the types of exercise that do not involve beating another person at something may be the real and lasting sources of health and happiness. Swimming, hiking, jogging, skating, cross-country skiing are examples. And it saves a lot of time wasted reading the sports page every day.

I realize this is probably a one-sided view of competitive and spectator sports. Certainly, many people derive a large amount of enjoyment from competing or watching others compete, and I may be missing a great deal, but I do think we Americans should seriously consider whether we really

are enjoying life by putting so much time and money into watching others do their exercise for us.

Illinois Geology Faculty: Good, Poor and Awful

When I first came to the University of Illinois, the geology department contained some rather well-known scientists, but there were two feuds in progress which made things unpleasant. Since all of that group are now departed from this earth, it may be permissible to describe the situation. Our senior members, Professors William Shirly Bayley and Thomas Savage were not on speaking terms. Bayley was a gruff but kind-hearted old man who was very competent in petrography and highly regarded by the U. S. Geological Survey. He said exactly what he thought and had apparently hurt Savage's feelings so badly that Savage would not speak to him. To the rest of us, Savage was a mild and pleasant gentleman. He specialized in paleontology and always seemed friendly and good-natured. Terrence Quirk, the department head, was an Englishman who had migrated to Canada and had been on the Canadian Geological Survey before coming to Illinois. He was rather cocksure, but a very nice person who, unfortunately, did not run the department very well. This caused a lot of friction with Morris Leighton, our Pleistocene geologist, who was a natural leader and I suppose should have been the department head. A continuous feud was raging between Quirk and Leighton, and we used to hear a lot about it, particularly from Quirk. Another assistant professor, Arthur Bevan was on Leighton's side and fireworks were frequent. I tried to be neutral and did manage to get along fairly well with all of them, and was glad to get some good advice from Bayley. Heaven knows I needed it.

Slight improvement came to the department a year after my arrival when Leighton was appointed to the position of head of the Illinois Geological Survey, where his executive ability pushed him and the Survey forward at an amazing rate. I decided I had sized him up somewhat erroneously during my first year at Illinois. Of course, many would say Leighton was largely a politician, but he certainly was a most successful one and he did worlds of good for the Survey and for development of the resources of Illinois. We need more scientific politicians of that sort.

We got a replacement for Leighton, Harold Wanless from Princeton, who was probably the best teacher that Illinois geology ever had and certainly the one who devoted the greatest effort to his students in addition to doing a tremendous amount of research on the geology of the Carboniferous. He was also very largely responsible along with Marvin Weller and Raymond C. Moore for getting the exciting history of the cycles of alternating submergence and emergence of the sea that characterized a considerable time in geological history. These three geologists are all dead now, but will never be forgotten by the geological fraternity.

Very soon our geology department acquired two Englishmen; Quirk had a weakness for Englishmen and both were in a sense his undoing. _____ Stansfield proved absolutely inadequate; He brought typed excerpts from books to class and read from them to the students as his lectures. Some of his class caught onto this and they would bring the same books and follow him word for word. Bill Howard, on the other hand, was a rather brilliant man but was probably the most evil character that I have ever been associated with. He had a mania for trying to have people fired. He joined a local

Unitarian church and, of all things, began a campaign to get the minister fired, and succeeded at it. Then he started on the geology department. He had taken a dislike to Quirk and decided we should get rid of him. Since universities are not very good at getting rid of professors, he got his protee mistress, who was a student, to tell the university dean that Quirk had made improper advances to her. Those of us who knew Quirk were sure this was not true, and we had been watching Howard operate for some time, and had discovered many of his fabrications; so we suspected what was going on. He also worked at firing another professor at the same time. An extensive trial developed with a university committee and calling of witnesses. We all testified, pointing out all sorts of nasty tricks Howard had been trying on faculty, townspeople, and students. The trial dragged on for many months. Finally the committee decided against Howard, but rather than firing him as they should have, they told him, "You have a year's notice and then your appointment terminates." Howard was very provoked and said, "To hell with you. I resign." Whereupon he picked up his mistress, leaving behind his wife, a very fine English girl, and their three young daughters, and moved to Oklahoma where there was no way his wife could obtain alimony from him. He just left them to starve to death. Of course the rest of us who knew the lady got busy and arranged to get her a job and provided means so that she and the children could survive. As it turned out, she did very well in a university job and retired many years later with a fine reputation.

Howard, on the other hand, kept going downhill, and finally committed suicide. He was penniless at the time, and the Oklahoma authorities actually sent a bill to his children asking them to pay for his burial. I never heard whether or not they did.

Two explanations existed for Bill Howard's evil ways. Perhaps the most important thing was that he was in the trenches in World War I for two or three years with little respite. The other thing was that his mother had wanted a girl, and when she got a boy instead she named him Vivian William which he always resented. Whatever it was, it seemed a shame that anyone with his ability should have wasted his life on scheming for the downfall of others. This professor was exceptional, and I am sure that families stayed together much better in the Illinois geology faculty than they have in the group with whom I later became associated at the University of California, but so far as I have seen there were no such villains on the La Jolla campus.

Professor Oldfather and the University Hikers

For me, all was not work at the University of Illinois. I must tell of some other aspects of our Illinois life. In any history of the faculty of the university there should be included an account of the Saturday afternoon hikers, who were inspired by the remarkable professor of classics, William "Bill" Oldfather, and which consisted of faculty members and a few graduate students. We gathered on the Oldfather front lawn in Urbana every Saturday at 2 o'clock, rain or shine, heat wave or sub-zero. This was the most democratic, free-speaking, intellectually honest group of faculty one could imagine. Some of us never missed a Saturday if we were in town. Volunteers brought their cars along, dividing expenses with the others and someone always bought thick, juicy steaks, rolls, and other provisions, also sharing the costs. The Oldfathers washed out the coffee cups, the few dishes and frying pans, and I am afraid were never thanked for it.

Bill would suggest a rendezvous location and the hikers would get into the cars and drive to one of the many valleys which cut through the otherwise uninteresting, flat Illinois uplands and afforded pleasant hiking in farm country dotted here and there with ponds left by strip mining of coal. In these ponds we could swim in warm weather, or sometimes skate in winter. We usually had a ballgame while some people hiked. I was a poor baseball player, but I did have unusual running ability, so if I could get on first base, I amazed all the group by stealing bases. The game was a lark, and the most venerable of professors would be kidded for his errors the same as the young graduate student. It always seemed to me that this was the kind of athletics a university should strive for, instead of those teams run by a coach who would brook no fun, and believed only in the importance of defeating the teams of other schools.

After the game or hike, everybody gathered wood which was always plentiful, and we built a campfire. Sometimes that building of a fire was a real woodsman's feat, as there were times when the snow was thick on the ground, or everything had been thoroughly soaked by rain. If the rain was falling, we would build the fire under a bridge. Our more sedentary colleagues at the university wondered about our catching colds from exposure of this sort. Actually, we were among the few among them who did not regularly have colds and flu, or at least I am sure we had fewer than the majority of others.

Around the campfire we usually sang old songs with great gusto, Bill Oldfather outsingng the rest of us with a strong bass voice. Then someone would start a discussion. Any subject and all sorts of opinions got thrown into the pot. Everyone could say just what he liked either about university politics or national politics. Intolerance did not have much of

a chance at those campfires, and the stuffy professors who ventured out with us once usually did not return, or if they did, they had to get used to being unmercifully kidded. For me, a young man when I went on these hikes, it was a liberal education. All sorts of departments were represented, and Oldfather could dig out information from experts along all lines. I think I learned far more than I did in my abortive sojourn as a Harvard undergraduate.

One result of those hikes that has affected my life pattern was that I really learned to swim. I had always tired easily before, and my feet seemed so heavy that I thought I could not float. One time while swimming in the strip mine (and we did actually strip in these deserted areas), a friend of mine, a professor of physical education, said, "Fran, would you like to know what is wrong with your swimming?" "Sure," I replied, "I get tired in no time." He told me to just take a slow stroke overhand, then breathe out slowly with my face under water, resting before my next stroke. I tried it, and to my amazement I found immediately I could repeat that routine and keep swimming without fatigue. I suppose I was 30 or so at that time, and all the rest of my life I have enjoyed swimming. When I reached the age of 80 I could still swim indefinitely without fatigue. What an effect a little thing can have on one's life. For years our vacations have been in places where I can swim to my heart's content. Now we spend half the year in Kauai where there is almost always good swimming.

CHAPTER V: THE BIRTH OF MARINE GEOLOGY

In memory of my father, Thomas Hill Shepard, whose loan of a sailing yacht for scientific purposes provided an opportunity to initiate studies of the sediments of the shallow sea floor.

Bottom Samples Collected from a Yacht off New England

I am often asked how I got into the study of the geology of the oceans, living as I did in Illinois. Perhaps the most amazing thing is that no other geologist, especially from coastal areas, got into this field except to study the beaches and other coastal related problems. My development of this new field was due to a series of accidents or coincidences, if you will. At Illinois we had a graduate student, George Ekblaw, who wrote his master's thesis on the Hudson Submarine Canyon, basing it on the charts off the New York area, and on a few short scientific papers by geologists written near the turn of the century. He showed the thesis to me and I was intrigued by it. Come summer vacation, 1923 I was pondering what to do since Elizabeth was pregnant and could not join me to work in the Rocky Mountains where I was still studying the structures. My father asked if I would like to spend the time at his summer place in Peaches Point, Marblehead, Massachusetts; to use his sloop, a sleek New York 40-footer, to do some kind of geological work. The idea rather appealed to me and I found I could get some small bottom sampling devices and a sounding reel that could be used to take samples off the New England coast. My father never reckoned on the amount of mud that was spilled on his clean polished decks, or he might never have extended the invitation.

Elizabeth and I traveled east with our new son Tommy in a basket, and after settling comfortably in ample quarters in the Marblehead summer home, I began planning my work. I marked a line for depths and practiced

with the sampling equipment from the local floating stage pier. Then I went out on the yacht with my father's crew and Elizabeth as my only assistant. We would take the baby and tie his basket onto the cabin table which was on gimbals so as to stay horizontal when the sloop was tipped by the wind.

Each sample required the vessel to come up into the wind; I would then drop the weighted sampler when our way had ceased, and hastily get our position from compass bearings on shore points as soon as the sampler hit bottom. Elizabeth kept notes on our results (the sampler often did not work under this type of handling). None of this seemed to bother our son -- he didn't cry even when his father swore.

To my surprise, I found almost everything brought up from the sea floor seemed to clash with the antiquated ideas that we had been taught in our geology courses. For example, we were told that sand is found along the shores and this, in turn, is replaced by finer sediments outside, and only mud occurs on the outer continental shelf. That is not what I found at all. Mud often occurred right near the shore and was replaced by sand in deeper water outside; then sometimes by gravel still farther out. I really got excited. Again the old masters seemed to be wrong and I, the knight in shining armor, was going to set them straight.

I decided to have a look at the nautical charts in the Boston offices of the U. S. Coast and Geodetic Survey and the U. S. Navy Hydrographic Department. I began poring over these charts and became even more excited by the interesting things I discovered.

The next year, 1924, I returned to Marblehead for the summer with a husky 6-foot student to help with the operations, and the promise of a trip to the Maine coast to take some samples in the deeper Gulf of Maine

and around Cape Cod. Our son Tom was old enough to be left with a nurse. We were getting more experienced and had somewhat improved our sampling equipment.

Father still had no engine in his yacht and I recall one episode when the wind gave out near a rocky island off Maine, and the current swept us right onto the steep, ricky side of the island. Our young Hercules (my student) jumped overboard and we passed him one end of the spinnaker pole which he managed to wedge against the steep slope. With his help we were able to push the yacht clear, but then he was left on the island in his heavy rubber boots. I had always heard that a man cannot swim wearing rubber boots, but swim he did, back to the yacht where we pulled him back aboard: Proof that rubber boots and swimming was just another old wives' tale.

On this trip my father and sister Katherine came along, but left the boat at St. Andrews, New Brunswick in the Bay of Fundy. And so, for the first time, I was in complete charge of the yacht. The steward who took the two ashore liked a drink; unfortunately he decided to stock up on liquor at the same time, since the United States was then in prohibition. He sneaked the stuff aboard but as we sailed over to Eastport, Maine the effects of his purchase began to become quite evident. In fact, he got completely soused. With the help of our young Hercules we managed to get him in his berth, thinking he would sleep it off. We confiscated all the whiskey we could find. Later, after we had all gone to sleep, he awoke and rowed ashore. We found him in jail the next day, sobering rapidly. When we got him out he wept all over the place, swearing to us he would never have another drink. When we got back aboard the boat a

Coast Guard cutter came alongside and we were informed that during the night the steward had sent a telegram to his wife reading "ALL LOST ON BOARD "CATHERINE" BUT MYSELF. SEND 10 DOLLARS FOR STITCHES." The woman had called my mother, who told her that Father and Katherine were en route to Boston on an overnight steamer and could not be contacted. This was not a good start for my using the yacht by myself, but Father was, in spite of his hatred of liquor, a broad-minded man and thought it was a good joke. My mother did not.

Voyage by Yacht to Newfoundland to Help Explain Deep Gulf of St. Lawrence

Two years later I persuaded my father to let me take his somewhat larger yacht, a 45-ft waterline ketch, DORELLO II, to Newfoundland so I could get some soundings and samples along the way. After the trip, when Father heard of our many narrow escapes on the way to Newfoundland, his comment was, "Guess I should have increased the insurance on the boat before you took that trip."

On this occasion Elizabeth and I, along with the captain and steward and three geology students set off from the Maine coast for Cape Sable, planning to make the crossing during the night. I was navigating and stood the first watch thinking I could safely lay a course for the captain to get by the rocks on the southwest side of the cape. However, the captain had an idea he wanted to navigate and after I had gone to sleep he changed our course. A few hours later I awoke feeling rather uneasy. I went on deck to find that the new course was heading us right toward the shoals. I immediately changed the course back, and

told the captain that he was not to change any course without consulting me first. We had a narrow escape, but the next morning we saw Cape Sable Light before dawn and safely rounded the southern tip of Nova Scotia.

After that we had slow sailing dead before the wind all the way to Cape Breton where we arrived some 6 days later and we had a day's rest in at Sydney before sailing to St. Paul Island in the entrance of the Gulf of St. Lawrence. We wanted to look for glacial striations to see if glaciers came out of the strait during the ice age to move across the shelf and produce the deep channel that runs all the way across the continental shelf south of Newfoundland.

I don't know how we missed the rocks coming into St. Paul Island in Cabot Strait. It was dark by then; we had no motor, and a somewhat inebriated lighthouse keeper rowed out to guide us in. When we woke up next morning we found we were surrounded by jagged rocks. We went ashore early -- Elizabeth and I and the students -- and walked to the other end of the island, finding along the way much vital information about glaciation of Cabot Strait during the ice age. At the north end of the island we crossed a narrow gulch on a chair connected to a cable. On the other side we met two boys who were tending the Coast Guard station. Both youngsters, like their parents at the other end of the island, were warding off the monotony of island life by drinking gin. I judged that alcoholism might be rather a problem on the island.

While we were talking with them they got a message over the radio from the other end of the island that a storm had come up suddenly and that our captain and steward were having a bad time getting their anchor

up to get out of the dangerous anchorage. They succeeded, and presently appeared along the east side of the island sailing with a heavy wind, and swinging around the corner where they hoped to find refuge from the storm, and also pick us up. With some help from the two islanders we managed to climb down the cliffs and get into the row boat the captain sent in for us. The storm was sending large swell around the island, and our anchorage was anything but comfortable. We actually rolled as much as 45° during the night, lying in the trough of the waves that came around the island from the storm. I kept thinking that the wind might change and leave us completely unprotected on the west side of the island, but it did not. We were glad to get under way next morning, and sailed across the strait to Newfoundland to Port au Basques without further trouble.

Newfoundlanders proved a most hospitable group. When we told them we were interested in looking at the coast around the corner and to the north, they arranged to take us for a ride along their coastal railroad in a small motor bus such as patrol the track. We found the glacial striations that we had suspected might be there if the glaciers were indeed coming out of the Gulf of St. Lawrence. We were also delighted with the beautiful scenery which the ride provided along the cliffed coast. We returned well satisfied with the results of our trip which had taken us to this little-known area of the southwest corner of Newfoundland. I was gradually building up a case to show geologists that the glaciers of the Great Ice Age had been most effective in excavating the deep gulfs formed along the coasts of glaciated territories which had previously been commonly explained by faulting.

We headed back across Cabot Strait to the Bras d'Or Lakes where, after an uneventful crossing, we met my parents. While at the lakes we entered the annual sailing race. My father was an expert in racing and we won. Afterward the local young sports, who decided that my father was too old for such horesplay, dumped me into the water as the winner. They tossed me up in a blanket and had other fun ceremonies -- fun, as they did not break my back. We dined that evening with the National Geographic ^{Grovesnors} Grovesnors, descendants of Alexander Graham Bell and delightful people who had a summer place on the lakes. We received a beautiful cup for winning the race, which my father kept and prized for a year until the next annual Bras d'Or Lakes race which he could not enter.

The Bras d'Or Lakes have a southern entrance connected by a canal to the open coast of Nova Scotia. When we left my parents we went through this canal and sailed down the coast of Nova Scotia, stopping only one night at Halifax before setting off on a continuous run to Marblehead. It took us only a few days as we experienced fair winds all the way and made better time than when we sailed in the opposite direction before the wind. The day after our return to Marblehead a powerful northeaster hit the area and we were very thankful that we had not had to cope with it, as it caused considerable damage to yachts along the coast. Again my father joked that he should have raised the insurance on what was not a very seaworthy boat before we set out on that voyage.

With such ventures into the marine area I found that I was rapidly becoming interested in marine science and losing my old enthusiasm for mountain structures and mountain climbing. A new career was in the cards. The dean of the graduate school at the University of Illinois made me a

grant that allowed me to obtain charts from all over the world and, with the help of interested students, I began to contour and classify the geological features of these charts, something not previously attempted. I also began to compile the notations of bottom character on charts from all over the world, finding that they contained an abundance of information showing that sediments do not consistently grow finer as you cross the continental shelf, but are about as likely to grow coarser, as I had discovered in my work off New England. I worked this information into a scientific paper which aroused considerable scientific interest, along with an equal amount of disbelief. One result was that Henry Stetson, who had also gone into geological ocean studies shortly after I did, was becoming convinced of some of these same ideas. We later were both thrown into work for the U. S. Navy during World War II, making charts of the areas of submarine warfare where the character of the ocean bottom was important to the prediction of the nature of sound transmission in tracking submarines.

With help from my students I contoured the relief of areas from all over the world, getting a much better picture of the continental shelves and of submarine canyons than had previously been available.

Studies of Charts of World and Challenge to Famous Douglas Johnson

As the result of these early attempts to invade the new and virtually untouched realm of marine geology, I began to produce scientific papers on a broad ranging basis, somewhat as I had in my earlier years of writing about mountain building and crustal deformations. There was one fundamental difference: Before writing these new papers I made a world-

wide study of sea floor conditions as they are so well revealed in hydrographic charts. This gave me a considerable advantage in my interpretation over those who were writing papers based almost entirely on what they had found in one particular area, and hence with almost no knowledge of what was to be found on the coast or sea floor around the rest of the world. As a result I challenged the opinions of various well established geologists and geographers because I felt their ideas did not seem to be reasonable in light of this wider study.

During my study of world charts, about the first thing I found was that the time-honored classification of coasts developed by the famous Professor Douglas Johnson of Columbia University just did not fit the facts. Again I was off to the races, challenging one of the big names in science. Since most American teachers of geology were using Johnson's classification as a simple and easy method of instructing their students, I stirred up another hornet's nest and was once again in hot water. In my ignorance I thought that once I pointed out some logical reasons why the old Johnson classification would not work, my discoveries would be accepted as new knowledge. I should have known more about the history of science and philosophy: I would have realized that this was by no means enough. Douglas Johnson was a great authority; I was a young upstart; geology teachers were not going to change their way of teaching simply because I pointed out some inconsistencies in this great man's superb classification. The method by which Johnson chose to combat my heresies is amusing. He may have felt he was above answering my paper himself, because he had one of his students answer it instead. Later on I became good friends with this same student and we have often laughed about it together.

I tangled again with Douglas Johnson about a so-called "Fundian Fault" along the Maine coast. My studies of the fault suggested that it was just one wall of a glacial trough due to a tongue of ice that had moved down the Bay of Funday during glacial stages and straightened the sides of the bay. I showed that similar straight walls are found along the sides of most embayments in glaciated areas and are not necessarily due to faulting. Once again Johnson had a student answer my criticism. In truth, neither that student nor I had any real information about faults of the area. Johnson was probably partially correct, as some old, obscure faults have been found along the relatively steep slope, but the trough was, of course, glacially eroded and straightened thereby. This all came out many years later, due largely to studies made at Woods Hole Oceanographic Institution.

Georges Bank off the New England coast was called a cuesta by Johnson, and I said it was a moraine dumped by the glaciers that came out of the Gulf of Maine. We were both right, as subsequent investigators with modern seismic equipment have shown. My methods may have been moving in the right direction, but needed much more study, as did those of Johnson.

CHAPTER VI: COOPERATION WITH THE U.S. COAST AND GEODETIC SURVEY

In memory of Captain R. S. Patton, Director of the U.S. Coast and Geodetic Survey, who did much to aid scientific research in becoming an important result of Survey operations despite the penny-pinching economies in the days of President Calvin Coolidge.

I become acquainted with Large Submarine Canyons off New England

In my attempt to develop the marine phase of geology I was given much very welcome cooperation by the U. S. Coast and Geodetic Survey. Back in the 1920's and '30's this survey was a small organization directed by Captain R. S. Patton. As he told me, the funds given to the Survey were pitifully small and research was completely frowned upon in the budgets prepared in the penny-pinching days of President Coolidge. However, Capt. Patton thought it a shame that even though we had developed echo soundings and a new method of establishing fairly accurate position well beyond the triangulation resulting from bearings on the distant land, new masses of soundings which were now being made could not be given some scientific interpretation. This seemed particularly significant when the Survey began to discover numerous submarine canyons off the New England coast on the seaward margins of the great fishing banks.

I had begun to get acquainted with the captains of the Survey vessels operating in this area and using Boston for their home port. Among these men was L. C. Colbert, a far-sighted man who later became an admiral and director of the Survey. These men told me of the interesting features they were discovering and invited me to come out on some of their trips. I accepted with pleasure, and watched with great interest as the sounding machine flashed echoes from this previously unexplored sea bottom. I even sat up all one night recording a sounding

line coming in from Georges Bank to Boston. All of this gave me fascinating things to work on; they let me have copies of their boat sheets with the new soundings on them and I was able to draw some fascinating contour maps of the new submarine canyons. I wrote a series of papers as the result of what I discovered from these trips, and from later trips to Washington to ^{pose} ~~pour~~ over the finished products of the new surveys.

One captain whom I particularly liked had a tragic end to his career. He happened to be transferred to the Philippines just before the Japanese attack on Pearl Harbor. He made a heroic attempt to get his ship out of Manila Harbor but was intercepted by the Japanese and everyone aboard was lost when the ship was attacked and sunk.

Prior to World War II the Coast and Geodetic Survey had continued their surveys down to Cape Hatteras and discovered many more submarine canyons; they completely surveyed the large Hudson Canyon that had been discovered a hundred or more years previously. I was able to accompany them on one of these trips off New York on what had formerly been J. P. Morgan's yacht, the Corsair. Commander (later Admiral) Paul Smith was along on that trip with his good friend A. C. Veatch, an old-timer of the U. S. Geological Survey who had recently become convinced that the newly discovered east coast submarine canyons were a replica of those valleys he had been contouring in his physiographic studies of the Appalachian piedmont; consequently I was somewhat low man on the totem pole. Veatch's contours made a great impression on the secretary of the Geological Society of America, Henry Aldrich, and when I tried my hand at contouring the area of the Hudson Canyon using the survey

obtained during the cruise on which I accompanied Veatch and Smith, Aldrich was considerably incensed since my contours did not agree well with those of Veatch and his partner, Commander Smith. Aldrich persuaded me to leave out my version so Veatch could have first chance at publication. This I did, but later had my young former student K. O. Emery try his hand at the contouring, and that version is published in some of my textbooks. Smith claimed that the Veatch-Smith contours were well verified by future cross lines made by the Survey, but I have shown that this is actually not the case at all. Wherever the Veatch-Smith contour has no good basis in soundings, they bring in valleys that are not at all borne out by the new lines.

One amusing incident in connection with that trip which we shared with Veatch and Smith was the result of my being put up in the quarters of the chief petty officers, thanks to the captain who cared nothing for scientific research. It happened that my room had previously been occupied by a person who evidently was not too cleanly in his habits. I awoke in the middle of the night crawling with bedbugs, on Morgan's old yacht, of all places. I got up and reported to the Officer of the Deck. He said, "Let's make sure there aren't any rooms left in the officers' quarters." He found one in the very stern of the ship where I luxuriated for the rest of the trip with only some propellor noise which was a bit troublesome. It was a rough trip and the old Corsair sometimes rolled to 45°. I felt sorry for old Mr. Veatch; he was quite seasick, but kept right on contouring in his stateroom. He was always good-natured and a delightful companion even though I did not exactly agree with his contouring method. The results of his contouring can still be seen on many Coast and Geodetic Survey charts of the east coast.

I Watch Surveying of Circular Hill off Mississippi Delta
Suggesting Salt Dome Origin

In 1935 I had my first opportunity to investigate the Gulf of Mexico. I became acquainted with one of the Survey captains, F. S. Borden, on one of my visits to the Washington office. He was assigned to the New Orleans district with the ship Hydrographer and was quite intrigued with some round hills he was surveying just west of the Mississippi delta. He phoned me and asked if I would like to go out with him for a trip. It was in the midst of my teaching, but with the help of the very sympathetic dean of the graduate school of Illinois, I got leave of absence for a couple of weeks.

Elizabeth and I found someone to take over the children and we drove down to New Orleans. She joined a college roommate in Mississippi while I went out with Captain Borden. It is a long and winding trip to the Gulf from New Orleans. During this portion of the trip I became intrigued by the deep water that we often traversed in parts of the Mississippi channel, more than 200 feet, and often on the outside of curves right along the shore. I had no idea a river could be so deep near its mouth. Also, I was impressed with the lack of any continental shelf beyond the river mouth where the ocean floor slopes down directly into the deep gulf. I began to get some ideas for some of my future investigations.

About twenty miles southwest of the delta we encountered the first of those strange round hills. As we surveyed it I began to get the strong impression that we were dealing with a salt dome. It was so different from anything else I had encountered in my studies of charts

from various parts of the world. It rises about 200 feet above the surrounding sea floor and is fairly flat on top. It is located right next to a trough-shaped valley which I later found could be traced by the new seismic methods into the margin of the delta and tied into an old channel of the Mississippi. We took one sample on the top of the circular hill and it had material in it which was also suggestive of a salt dome, though not conclusive evidence. I found there is a series of somewhat similar hills along the edge of the continental shelf farther west which had showed up on some previous recent surveys by Captain Borden, and I got the soundings from these.

On my return I put the information together as quickly as possible and submitted a paper to a scientific journal suggesting these rounded hills could well be salt domes like those that had proven so important to the oil industry on the gulf coast both in the Mississippi delta and west into Texas, where they had been drilled. In fact, these salt domes and their surrounding oil fields had rather recently caused a great boom in the oil industry. Curiously my paper was not given much support at the time and various authorities among oil geologists argued against it. Now however, there is no doubt but that many of these hills on the continental shelf actually are salt domes that have pushed up ^{the} surrounding formations. Consequently the oil companies are making millions of dollars through their exploitation.

I get some Insight on Remarkable Topography off Southern California

My association with the Coast and Geodetic Survey operations off southern California actually began earlier than the trip to the Gulf

of Mexico, but continued longer and might as well be given in geographic sequence.

I was given a sabbatical leave from the University of Illinois in 1933 and '34 and moved with my family to southern California where I anticipated making some studies of the submarine canyons, most of which head in so near to the shore that they can be investigated from small boats. I obtained a couple of small grants of just a few hundred dollars to make such studies, but I immediately got in touch with the Coast and Geodetic Survey office in Los Angeles and found that the commanding officers of their two locally operating vessels were both very glad to have me take trips with them. Captain Swanson of the Pioneer, which was fully equipped for making echo-sounding surveys, and Lieutenant Bob Knox (later Admiral and director of the Survey) of the 75-foot Romance was taking mostly wire soundings around the islands. Capt. Swanson and I became good friends and I particularly enjoyed going out with him while he surveyed some of the local submarine canyons and provided me material for helpful studies of many of the southern California marine features which I was able to use in my future work. One slight mishap occurred at the end of one of our trips on the Pioneer.

It was just before Christmas and relatively cold, and he planned to set me ashore on a pier at Malibu, as we were then living near Santa Monica, and he was continuing up the coast. It was early evening and misty, and since this was before the days of radar, his position was slightly off so that what we thought was the pier turned out to be lights from the houses along the coast. Two oarsmen and myself put off in a small boat toward the lights, but found no pier. The men asked, "Do you mind going

in through the breakers?" Foolishly I said I didn't, whereupon we immediately hit an unusually large breaker at just the wrong time and over we went, maps, briefcase and all. The rowers were both strong swimmers, and I was pretty good myself, so we made it ashore on the next wave, me holding onto my briefcase while one of the others had grabbed my roll of maps. They signaled the ship by flashlight while I headed for the road and encountered a barbed wire fence that was not easy to get over. I finally found a place where I could make it and walked up the road to a restaurant where I went in all dripping wet and asked if I might use their telephone. They at first thought I was a drunk, but they did let me use the phone and I called Elizabeth in the not-distant Santa Monica Canyon where we had a small cottage. She drove out and rescued me. There were great apologies later from Capt. Swanson; he told me he had fired the crew who gave me my pre-Christmas dunking in the Pacific, which I was sorry to hear.

Later, going out in a much smaller 75-ft launch with Bob Knox, I was present when he made a survey around Catalina Island. This gave me a good opportunity to see how the Survey made their locations and took vertical cast soundings for an onshore survey of the kind which I later made at several canyon heads from skiffs. On the outside of the island it was quite rough and pretty nerve-racking when we got close to the coast and the breaker zone. It was, however, an experience I have always cherished and it was certainly of great help to my future work. The views of the island are quite breathtaking, particularly as close to the great cliffs as we got. I later wrote a paper using the information and discussing theories of the island's origin.

I am Shown Some Indication of Northward Continuation of the
Great San Andreas Fault

A few years later I got an opportunity to work off northern California. I remember this trip both for the exciting scientific discoveries which it encompassed, and because of the rough sea which was nearly continuous, and which gave me some queasy feelings in my digestive system. One of the officers who had considerable seasickness claimed there was some kind of gas escaping from the fathometer that was making things much worse. At any rate, I had to struggle to keep from going to the rail.

As we steamed north we plunged into head seas built up by 40 mph winds. I was told that north of Point Delgada where there had been considerable damage to the small community during the 1906 San Francisco earthquake there were indications that the San Andreas fault had moved with its horizontal shifting of ground as had occurred at San Francisco. North of this point a submarine canyon extends into the coast and the chart indicated that where it came in there was no land valley, but only a steep cliff. One of our assignments on this trip was to sound out the head of this canyon. The captain said it would have to be accomplished from one of their 30-ft launches which they carried for near-shore work. Seeing the 40-mph gale that we were plunging into, I wondered how they could possibly get a launch over and make this survey. It seems there is a peculiar meteorological condition near the coast: As you come in, the gale stops and there are only gentle winds coming mostly off the land. I volunteered to go along on the launch and watch the survey. Of course, even though the wind had virtually

ceased, the swell from the wind waves outside was coming in and huge breakers could be seen all along the mountainous coast. During the survey we sometimes got so close to those breakers that I wondered why I had been so foolish as to go along, but we always turned in time to avoid being destroyed by the breaking waves and a survey began to appear that showed very clearly that the head of the canyon had an escarpment parallel to the shore with a slope as steep as 45° in some places. Clearly the canyon had been cut off by the horizontal movement along at least a portion of the San Andreas Fault. That explained why there was no valley along the shore that corresponded with the canyon seaward. Later that day we went into Shelter Cove at Point Delgada and I saw further evidence of that offshore wind. As we were anchored that evening a sudden gust of hot wind hit us as it came down from the mountains; a blast with winds up to 40 miles per hour. This is an extreme example of what we call a "Santa Ana" that often blows from the mountains of southern California out over the sea and brings warm air down from the mountains due to compression.

We continued next day farther north and surveyed the continental shelf off Point Gorda, finding a series of elongate depressions and ridges at the shelf edge, an unusual feature for a continental shelf, but explainable if the San Andreas Fault had been subject to what is called strike-slip faulting along that area in recent geological time. Furthermore it is just up-coast from here that a great escarpment bends westward, completely altering the topography of the sea floor from that seen farther south. This escarpment rises as much as a mile above some depressed areas to the north and extends seaward along the north side of

a ridge. Although my original interpretation of this remarkable feature was not entirely correct, it certainly gave the impression that it was the result of a considerable movement along the San Andreas Fault which had been deflected seaward at Punta Gorda. Judging from the displacement of the contours on the two sides of the escarpment I figured that this showed an offset along the San Andreas Fault of at least 40 miles. This was in line with what some geologists had claimed, but others, including some of the old timers among California geologists, in particular, Andrew Lawson from Berkeley, and the well known Ralph Reed of Los Angeles, scoffed at the idea of large displacement and paid little attention to my idea. Of course that was 35 years ago and now that plate tectonics is completely taking over the field, it is standard doctrine that displacement along the San Andreas has been a matter of not 40, but hundreds of miles. However, the Gorda Escarpment appears to be related to one of the many fracture zones of the Pacific, in this case to the Mendocino fracture zone which extends on farther west and it is not entirely clear just how it relates to the displacement along the San Andreas Fault. One thing at least is certain; the San Andreas fault does not cross the Gorda escarpment as many seismologists used to claim. What they failed to note was that the escarpment is not offset where they had the fault crossing it, as I tried to point out many years ago.

Our cruise had one more port of call where we stopped at Shelter Cove on the way south. As one of the technicians was driving south from there, I asked permission to join him and had the opportunity to go and get a look at the coast along the cliffs as far north as the lighthouse

as Punta Gorda, and to make a preliminary study of the geology along the land where I thought the San Andreas Fault zone existed. The formations were certainly indicative of considerable faulting with slickensides and large amounts of vein material showing in the metamorphic rocks of the cliffs. Thus I was quite happy about the case that I was able to develop for the great fault, or what now seems more likely, the fault zone extending right along the coast in this area.

I get some Soundings of the Great Canyons off Sri Lanka (Ceylon) and Swim in One of Them

Although my principal opportunities to accompany U. S. Coast and Geodetic Survey ships developed prior to 1937 when I began my studies with the use of oceanographic ships, I did have several chances at a considerably later date. One such was an interesting voyage down the Bay of Bengal to Sri Lanka (Ceylon) on the Pioneer in 1964, which I joined on the invitation of my friend and former student, Harris Stewart, who was the chief scientist of the expedition. On the way south we made some preliminary studies of the extensive channel system which extends the entire length of the bay and is partly a continuation of the large trough-like valley which heads off the mouth of the Ganges Branhā-Putra River system in Bangladesh. The intertwining channels that run along the entire bay are in great contrast to the large canyons which extend out from Sri Lanka. We had hoped to make some good charts of these canyons, but the government of Sri Lanka was unfortunately suspicious of United States intentions and refused to let us inside the 12-mile limit. Even so, we made a moderately good survey of the outer part of the great canyon that is known to enter Trincomalee Bay. It is of

particular interest because the rocks around the bay are quartzite, so that we see a submarine canyon cut into one of the hardest of all rock formations. Furthermore, this canyon and the various other canyons which we crossed to the south of it are all located off the principal river valleys and thus give somewhat the impression of being the drowned remnants of old land canyons; this is a much debated subject among geologists.

This cruise ended at Colombo where Elizabeth joined me. She had been touring Sri Lanka and became much attached to a young Ceylonese and his two youngsters; he had been her driver and guide for several interesting tours including some fascinating ruins. We invited two friends from the ship and hired her driver again for a dual purpose. One was to see these remarkable ruins and the other was to make a dive into the head of Trincomalee Canyon where it came in to the shore. We were actually able to see the quartzite rocks into which this canyon is cut.

Our visit to Colombo was made interesting as we were entertained by the American Ambassadress, a lady by the name of Willis, due to arrangements made by Harris Stewart. In turn we gave some short talks about our work on the Pioneer for her benefit. The political situation was getting rather difficult in Sri Lanka at that time and the money exchange was quite a problem. However, our driver apparently had some connections for we did not have to pay the ridiculous rate of exchange at the banks when we paid him for our tour.

CHAPTER VII: GRANTS FROM THE GEOLOGICAL SOCIETY OF AMERICA

In memory of Dr. Harald Sverdrup, Director of Scripps Institution who made the Institution a truly great sea-going laboratory of oceanography and was responsible for my obtaining a considerable grant from the Geological Society of America.

Prior to 1937 my studies in marine geology had been dependent on very small grants from various scientific societies, from my own university, and as indicated previously, to an important degree on my participation in a number of operations with the U. S. Coast and Geodetic Survey vessels. In addition, I had the helpful cooperation of Scripps Institution under their Director, T. Wayland Vaughan. I had made certain studies of the canyons along the California coast including the taking of detailed wire soundings in the amazing canyon head, with its precipitous walls, just north of Scripps Institution in La Jolla, and of the granite gorge that heads into several arms of Carmel Bay. The reported results of some of this preliminary work led to operations on a much larger scale. I realized that I might some day be able to obtain funds that would allow me to carry on operations involving ships and complicated sampling equipment that would permit me to get out of this pauper type of research and go full speed ahead with investigations of many of the fascinating problems of the ocean floor. I little realized then how close I was to making a large step forward, during those years in the mid-thirties. The chance finally came in early 1937, and I shall describe how frustrating it was at first, after luck seemingly turned my way.

Penrose Grant: A Great Boost and a Peck of Trouble

When my former mineralogy professor at Harvard, Charles Palache, became president of the Geological Society of America, the Penrose millions had recently been added to the endowment of the Society following

the death of this outstanding mining geologist. Small grants, a few hundred dollars apiece, had been given to many geologists from the Penrose research funds. Palache said, "Why not give one or more large grants?" and went on to suggest my work in marine geology as something which might be supported if I could submit a worthwhile project.

Getting in touch with the new director of Scripps Institution, Harald Sverdrup, I was fortunate to find that Scripps had a new ship, a 96-ft power schooner, recently given by the Scripps family trust, and Sverdrup had insufficient funds to operate it continuously. He suggested that I ask for \$10,000, for which I would get use of the ship for six months, as well as a small salary and some other trivial help. This was the first great break in my career and I was wild with enthusiasm. The Geological Society made the grant, but chose a committee who would watch my every move; the committee was composed of well-known geologists, which suited me fine. I thought.

Whereupon, I got leave of absence for a year from the University of Illinois and dropped my plans to go to the Russian International Geological Congress in the summer of 1937. Instead I headed for La Jolla, arriving well ahead of my family, ready to go to work. I brought two promising graduate students with me. This was the best move I could have made. Both students later became famous geologists: K. O. Emery and Robert S. Dietz. When I arrived with the strange idea that I could go out to sea immediately, as I had in the Coast and Geodetic Survey ships, I could not have been more mistaken. The new ship, the E. W. Scripps, was still being overhauled; no date had been set to sail. Equipment was almost nonexistent. It looked as if I was going to have a half year's

wait, and I had only a year's leave of absence. Of course, my review committee was soon breathing down my neck, and I was frantic. I guess this is when I first got the nickname "Frantic Fran."

While waiting impatiently I did considerable planning with the new Scripps instructor in geology, Roger Revelle. (I often did seem to associate with future great men in their early stages of development.) Anyway, Roger and I decided to subsidize Eric Varney and Lowell ^eRidwine, students at the University of California in Los Angeles, who had an idea for building a coring device that would, they thought, and with some reason, revolutionize coring of the sea floor. A vacuum in the core tube would break when it hit bottom and would allow the taking of tremendous cores by implosion. It was finally tried, with much ceremony. Everyone took pictures as the device went over the side, but when it came up it looked like the cats of Kelkenny: "Of the cats there wasn't any." Our funds went down the tube; fortunately for me, mostly Roger's. Emery and Dietz asked me for a hundred dollars and, using spare parts, they built a good coring device. They realized and made use of the fact that the nose on the core barrel should have a smaller diameter than the barrel itself, thus decreasing the friction as the core came into the barrel. This device actually beat the much-touted Piggot gun corer that was considered such an innovation at that time, and even got us one core 16 feet long, a new record.

During this period of waiting for the ship to be ready for operations, I became fascinated by the beach changes that were occurring along the shore in the La Jolla area, which was exposed to sea attack by open Pacific waves. With E. C. LaFond of the Institution, and my young

assistants, I got some interesting programs going that later brought dividends, but none of this was work for which the \$10,000 grant had been made. Finally in January we went out on the E. W. Scripps. It was on that trip, with Sverdrup along, that we had our big "implosion" of the Varney-Redwine core tube. Also, we broke most of the china on the E. W. Scripps on this trip while getting out of Pyramid Cove on San Clemente Island when a sudden storm made us leave our anchorage in a hurry to get out to sea in the middle of the night. No one seemed to have prepared for such an event on the newly equipped oceanographic ship. Which reminds me of how badly I impressed our captain, a local yachtsman. I gave him a course which was 180° in error and would have piled us up on the rocks. Like my father, this captain was a yachtsman and was not pleased that the decks of the E. W. Scripps were often dirty with mud samples. He loved to use the sails and it was quite a treat to coast along with all sails pulling and no motor to interrupt the peace of the ocean spaces. Unfortunately the sails were used less and less as time went on, and motors seemed much more practical for this work.

We had another adventure while exploring the sea floor around San Clemente Island. We anchored one night at Wilson Cove at the north end of the island where a small Navy establishment existed, under the charge of a ^{lieut.} Lieutenant. We went ashore and asked permission to walk across the island to have a look at the famous terraces which are used as an example of elevated sea cut terraces in many geology textbooks. They are about as fine as any I have ever seen, and run continuously along the west side of the island. While we were looking at them we were

somewhat disturbed to have shells from the Navy target practice come soaring over our heads. We wondered if the Lieutenant had reported to the ships that we were walking around on the island. To return to Wilson Cove we intended to go around the north end of the island, but decided that probably was where the target was located. Our hunch proved correct, and as we returned over the top of the island we actually saw the Navy ships firing on the area we would have traversed if we had not been warned by the earlier bombardment. We decided we had better stay clear of that island, both on land and on the sea, where an interesting escarpment existed on the northwest side of the island.

Seaward of San Clemente Island were various shallow banks, one of which rises almost above sea level and creates dangerous breakers which have trapped many vessels. We passed near the shallow spot and were somewhat horrified by the pileup of waves which roared across this shallow rock away out in the open, far from any land. We collected samples from the bank, including various types of rock, and we were able to identify their age by fossil content. Still farther out we came to the Patton Escarpment which I had named after Capt. Patton of the Coast & Geodetic Survey. This great underwater cliff is comparable in height and steepness to the east wall of the Sierra-Nevadas. It differs, however, in having almost no canyon-like valleys along its length which was verified by our soundings. We made a dredging along the escarpment which was somewhat perilous as we had to let out virtually all our large wire and the weight was so great we feared we were exceeding the strain limit for the wire, as the gauge reached its limit long before we started to dredge. However, we pulled slowly up

the slope, praying the wire would not part, and finally hours later we wound it all in and the dredge was still attached, and even contained a small rock which we were able to date.

In our operations outside San Clemente Island we almost invariably encountered rough weather and so we used to refer to that area as the cactus patch. My son Tom went along on one trip. He proved to be a fine sailor and when it got so rough that our cook could not operate in the galley, Tom took over and did very well by us. He has always loved the sea and sailing is his hobby and joy, like his grandfather.

One of our most adventurous trips was up the California coast around Point Concepcion, and continuing north to Monterey Bay where the Monterey Canyon exists. It is the largest of all west coast submarine canyons. One of its profiles is quite comparable to the Grand Canyon of Colorado, as determined from some of our soundings. We obtained a core in this canyon which was of great satisfaction to us as it showed muddy sediment at the top, underlain by sand and finally by gravel at the bottom. Unfortunately I interpreted this as an indication that the canyon had a subaerial origin. Now with all the similar discoveries in other submarine canyons, I have of course realized that turbidity currents is a better interpretation.

So we finally began to learn about submarine canyons, which was the purpose of the \$10,000 grant, but even then my committee was not happy. They were mostly convinced that the canyons had nothing to do with river erosion and in those days I was a strong advocate of ancient drowned rivers as the cause of the canyons and I apparently found evidence to support my hypothesis. I have had to eat crow a lot in that

regard during the past 30 or 40 years, but now maybe the pendulum is swinging a bit away from the contention of Daly and others that turbidity currents are the sole cause of the marine canyons. If you live long enough, your crazy ideas may come back into vogue.

Anyway, I did get six months' use of the E. W. Scripps after having my leave from the University of Illinois extended to a year and a half, with some grumbling from Illinois University authorities.

The grant gave me an entering wedge into Scripps Institution, and I began teaching less and less at Illinois, hence making my family live on less and less income until finally the war created a completely new arrangement.

Expedition to the Gulf of California

In 1940 Roger Revelle and I applied to the Geological Society of America for a grant to support an expedition to the Gulf of California on the E. W. Scripps. This was accepted and we enlisted the help of Charles Anderson of the Berkeley Geology Department who later became the Chief Geologist~~s~~ at the U. S. Geological Survey, and also of Wyatt Durham of the Berkeley Paleontology Department, to study the land geology of the islands and coastal areas which we would make accessible to them. We were also fortunate to still have K. O. Emery and Bob Dietz as graduate students, and they were more than anxious to go with us. The only serious error we made was in starting the expedition in early October when tropical hurricanes (Ch^ubascos) were still quite likely to occur in the gulf area, but we had no knowledge of that, and fortunately did not hit one of these storms.

Our start was somewhat delayed because Sverdrup told Revelle that he would have to finish a manuscript on current-meter studies before he could leave, but as usual, Revelle talked Sverdrup into letting him go.

On our way we stopped at Guadalupe Island 300 miles off the coast of Baja California and saw some of the remarkable herds of sea elephants. After putting our land geologists ashore to collect island rocks, we made a tour around the island to study its bathymetry for the first time.

Continuing south towards the entrance of the gulf we passed well clear of the projecting Baja California coast at Magdalena Bay, but were surprised to find that our fathometer was recording a clear echo during one night of less than 100 fathoms. We thought we must have discovered a shoal well out from the coast, and stopped to take a sample of the bottom, but found we actually had very deep water. What we had found was an indication of what is now known as the "deep scattering layer," an echo that comes from a layer of abundant plankton (small animals and Plants) in the water. This layer moves up near the surface during the night hours and is recorded on fathometers as if the sound were reflecting from the bottom. A few years later, during World War II investigations, my colleagues Martin Johnson and Russell Raitt properly interpreted this deep scattering layer that moves up each night and down each day, related to daylight and darkness.

At the entrance to the Gulf of California we spent a day making a survey of a submarine canyon which 20 years later I had a chance to study in considerable detail by other means. We worked our way north up the gulf, encountering some of the strong north winds that made progress slow and painful. We had to use the sails and tack back and forth, smashing into the short head seas.

We were greatly impressed by the abundance of fish which we encountered all along the route up to Guaymas. Trailing a fishing line at the stern, we had no difficulty catching a constant supply for the galley as we traveled against the wind at slow speed. We ran our fathometer constantly, recording the sounding for our future map of the gulf. So far as we could judge from our astronomical fixes the positions of some of the islands, and even their length, were quite inaccurate on the available charts made mostly by the U. S. Hydrographic Office around the end of the 19th century. Taking an occasional core in some of the deep basins in the gulf we discovered the unusual sediment, diatomite, a microscopic siliceous plant, a type of plankton. We also observed some red-looking water which had given the gulf its original name, the Vermillion Sea. Billions of small red crabs (called galathea . . .) were drifting along the surface in the northern portion of our traverse where the sea was less turbulent and we could observe these small ^{pelagic?} planktonic animals. ✓

Two weeks after leaving San Diego we arrived at Guaymas where we were met by Elizabeth and Ellen Revelle who had driven with Claude Z^Bobell, ✓ a Scripps microbiologist, in our car to the area. They had learned that Wyatt Durham was detained at the train station at the border because he told the Mexican authorities he was coming in to do scientific work and he had no permit to do so; the Mexican officials wouldn't let him in. He was bringing the ladies' suitcases with their outing clothes, because the car was full of new instruments for the ship and there was no room left over for suitcases. The Mexicans noted the ladies' clothing and were highly suspicious of Wyatt. Fortunately we had some scientific friends in Mexico City; we called them to help us untangle the mess so that Durham and the girls' luggage arrived. They were glad to have something to wear besides home-

made bandana bathing suits for their beachcombing. I might add that they were somewhat astounded at our appearance on our arrival, as we had all grown beards during the two weeks that intervened ^{before} our rendezvous; beards were not nearly so common on men in those days. They also said they did not know whether the warm reception we gave them was for themselves or for the case of brew they had brought. When we first dined at local hostelrys we must have made quite some appearance, with the girls homemade costumes and our shaggy beards.

The next few months gave us a fine opportunity to make a reconnaissance survey of the geology of the gulf, both of the sea floor and of many of the islands on which we left our land geologists for a few days at a time. They discovered one volcano along the west side of the gulf which appeared to have been active in comparatively recent times. Previously such recent volcanic activity was unknown in Baja California.

We were impressed with the general absence of continental shelves along the west side of the gulf. We were also impressed by the absence of elevated wave cut terraces along the west side of the gulf, whereas they were very obvious on the east side.

Whenever our land geologists were off on an island or on some part of the coast the rest of us were overworked as we had to stand 6-hour watches instead of 4, in order to tend to all the ship's duties. Thus it was a relief to have them back.

We were interested in the discovery of many steep escarpments along the west side of the gulf. I was also much excited to find a series of diagonal fault scarps running NW-SE along the gulf, and made the suggestion that this represented the southward continuation of the San

Andreas Fault system, known to run along the Imperial Valley farther north. We now know that what we had actually encountered was the northward continuation of the East Pacific Rise into the Gulf of California. The latter is now considered to be a rift valley like the Red Sea, and the rift valleys of the mid-Atlantic Ridge, which play such an important role in the Plate Tectonics Hypothesis. The San Andreas Fault at the head of the gulf fits nicely into the evolving picture, according to many recent investigators.

After our exploration of the gulf, the expedition came to an end at San Diego on December 23rd, when we arrived just as a great storm was hitting the area. We had seen evidence of its coming by the huge swells that were surging by us as we advanced slowly up the northern part of Baja California. Fortunately we got in to port just before the worst part of the storm hit.

CHAPTER VIII: MARINE GEOLOGY STUDIES FOR THE U.S. NAVY AND
EARLY POST-WAR COASTAL STUDIES

Dedicated to Dr. Gaylord H. Harmwell who took over the direction of the University of California Division of War Research at Point Loma, San Diego in 1943 and with his splendid administrative abilities convinced the Naval authorities to transfer the Navy captain who had made it impossible for our laboratory to cooperate with the Navy lab which was working on the same, or very similar projects.

Leaving the University of Illinois and Joining the University of California
Division of War Research

My connections with the University of Illinois, which had become rather fragmentary, terminated shortly after the Japanese attack on Pearl Harbor. I had planned to spend only a semester at Scripps Institution when we left Illinois in February of 1942, but actually spent the rest of my career with the University of California, mostly at Scripps. With our two children and a dog we drove west with one bad tire. We had a blowout near Little Rock, Arkansas, which forced us to use the poor spare and we wondered how we would ever get another one; they were not selling any tires at that time. Fortunately our relatives in Little Rock were able to get us a retread which actually lasted for the rest of the war.

On our way west I gave various lectures that had been planned by the American Association of Petroleum Geologists' Distinguished Lecture Series before war constricted such activities.

On arriving in La Jolla I immediately joined the air-raid wardens and that very first night the air alarm went off and I raced around warning people to extinguish their lights by throwing gravel at their screens wherever lights showed. Great excitement, but just a false alarm, of course. There were not any more "attacks" on the west coast by Japanese submarines, to say nothing of planes; just rumors.

I was desperate to get into some kind of war work that would use my new branch of marine geology. I had applied to the Hydrographic Office with no result. Learning of the University of California Division of War Research with a group at Point Loma, San Diego, I applied immediately and in a few days, after a cursory examination of my political background and family (luckily they did not learn I had once been a branch president of the League Against War and Fascism, though I resigned after finding out it was a Communist front), I took up my work with the Navy Radio and Sound Laboratory under a separate director for the university branch. There I found that I could contribute something that might really help the war effort.

Now that it can be told, it is amazing what was going on in that Navy Laboratory from a management point of view. The Navy captain in charge seemed to have one main purpose in life: to stop the University of California branch from doing anything useful and to keep us in the dark about what his laboratory was doing. This same captain is said to have been the man most responsible for developing radar in the Navy, and he apparently kept it all so hushed up that our Naval command at Pearl Harbor did not have any confidence in the early reports of the Japanese attack. Maybe that is just a story, but it sure made the rounds in those days. Anyway, this captain just about stymied all our early efforts until our University branch director finally resigned and we acquired a new administrator, hard-slugging, knowledgeable Gaylord Harnwell (later president of the University of Pennsylvania). He pounded the table and persuaded Navy authorities to realize what was going on at Point Loma,

no doubt with some assistance from Roger Revelle who was fast rising in his Naval Reserve appointment in Washington. We were free at last to make our contribution.

We had good support for our marine work, despite some trouble in getting wire for our own winches. It was old and rusty, and we lost numerous dredges. The only times we realized we were really in a war was when the Navy planes confused their target area boundaries and dropped torpedoes around us or sent a burst of machine-gun bullets along our rails. Once the torpedoes passed close by us on either side. At least we hoped they were not loaded, but they could easily have gone through our ship's wooden hull.

In general we had good captains on the small research ships from which we operated, but sometimes we would get one of the "90-day wonders," a reserve officer, and unbelievable things would happen. Once we pulled out from Point Loma in the fog and the captain got mixed up and ordered us up San Diego Bay instead of down; I whispered to him that he had better turn around if he wanted to get out of the bay. Another time, operating in San Francisco with the tide running strong, one of these captains with a couple of very shiny stripes on his sleeve had to bring a small ship in to Treasure Island (the old fairground converted to a Naval base during the war). He was having a bad time with the currents and just could not come alongside the dock properly. An admiral happened on this scene and grabbed a megaphone and began giving orders from the dock. The poor skipper's face got redder and redder until he finally brought her alongside and the lines were secured.

The most pleasant episode of the war for me was the three months during which I was sent with some other volunteers to Hawaii and Midway to investigate the bottom character of the approaches to the main harbors of the islands for installation of sound-detecting devices. The day I arrived I had quite a shock. It was a Saturday and Pearl Harbor was almost deserted as most personnel were taking what was called "exercise liberty." I was in a laboratory where, I had been told, there were all sorts of secret documents when in came a group of orientals who looked like Japanese. And what were they doing? Changing the locks on all the desks and file cabinets. I was dumbfounded. I soon learned, however, that no one felt suspicious of the Japanese in Hawaii so long as they had some kind of clearance. In California we were evicting Japanese from the state; they were too important in the work force in Hawaii. Strangely enough, they proved amazingly loyal despite their Japanese language school programs. Since then they have taken over the political scene in the islands. Luckily they don't have Japanese as the required language as the French do in Quebec.

The trip to Midway was really a bonanza for those of us who like to swim. Our scientific gear got misplaced and did not arrive at the island for 10 days, so we had time to explore the reefs with our face plates. The Navy personnel may have thought duty at Midway was like being in jail, but to us it seemed more like paradise. I had never swum on a reef before and was fascinated by the fish and corals.

I did have one narrow escape. I was crossing a channel between two reefs when I encountered a tremendous outpouring of water from the

lagoon inside. I could not swim against the flood and would have been swept out into the large breakers if I had not managed to grab a coral head and hang on for dear life for a few minutes until the surge abated. That taught me something about reefs which I have incorporated into my textbooks ever since then. On another occasion an unusual breaker came in over the reef where I was standing and I was rolled over and over, getting numerous lacerations. When I went to sick bay the doctor said, "This is what I have been looking for -- somebody to try this new sulfa drug on." He gave me a good coating of the stuff. I was afraid that would be the end of my swimming but no: in a few days I had recovered and was back in the swim.

We did have a couple of air-raid alerts. It was in 1943, not long after the Battle of Midway. I remember our small craft stripping for action and wondering what it was going to be like but, again, a false alarm. Our only visitors were the goonies^{eyes} (albatross) who frequently invaded the airfield and made it difficult to land planes. These birds, so graceful in the air, looked like clowns on land. Their antics so engrossed our drivers as to cause many small accidents when the drivers watched the birds instead of the traffic. The gooney birds never seemed to realize that their happy breeding ground had been taken over by war activities.

After finishing our work at Midway we flew back to Honolulu where I had a much narrower escape. I came home to the Moana Hotel one evening and went for my usual swim at the famous Waikiki Beach. I was rather surprised that there was no one on the beach, but went in anyway. All of a sudden all hell broke loose. The Navy was having a practice in

repelling landings and had ordered all beaches cleared so they could shoot out over the approaches. I swam underwater most of the way to shore and emerged in front of the hotel, sneaking back unharmed, but my nerves were the worse for wear.

Our stay in the islands finally came to an end and we went back to Point Loma for the rest of the war, except for the last two months when I got into beach studies for landing operations. I had one interesting experience in that beach work. We had been studying Japanese beaches and when I went into a Marine colonel's office I recognized a relief model of the beach east of Tokyo where they were considering a major landing. I was amazed -- right out in the open, a wonderful chance for a Japanese spy, if there were any left by that stage of the war.

Beach and Coastal Studies

After the war I finally resigned from the University of Illinois and was given an appointment at Scripps Institution under one of the continuing military contracts. I hoped to be able to continue some of my investigations of submarine canyons, but instead began working with my good friend, Parker Trask, on a Beach Erosion Board contract at Scripps. We had the use of a Dukw (built for war-time landing operations) and a stocky little Italian driver. He could drive us nonchalantly through the breakers, keeping right on a range so that, with the fathometer running and surveyors stationed on the beach checking our position every minute, we could obtain accurate profiles of the sand levels beneath us and were able to find out what various types of waves would do to beach approaches where troops might have to land. Those trips through pounding breakers

were a real thrill and we often wondered if we would live to tell the tale. The Dukw driver deserved his pretty young wife.

We began an investigation of the changes in beaches caused by storm conditions, and with the help of WPA workers we took soundings along piers and later used the Dukw to find how depths changed under various conditions. This was really a continuation of what had been started while I was waiting for the E. W. Scripps to go to sea back in 1937.

These coastal erosion studies up to 1947 showed that the alluvial cliffs near Scripps Institution were continuing to be cut back almost a foot per year where they were not protected by sea walls, as T. Wayland Vaughan had shown early in the 1930's. Every year the beach area to the south of Scripps would have most of the sand cut away, gravel would appear in large quantities, and then the cliffs would be undermined and begin to retreat. At this time I made a hasty and unwise prediction to my marine geology class at Scripps Institution. I said to them, "You see the sand along the shore out in front here, but just wait. Come winter storms, that sand will mostly disappear and gravel and cobbles will take its place." The fates must have heard me because for the next 31 years the sand almost never disappeared and the sand beach was a continuous feature throughout the winter. Concurrently, erosion of the cliffs virtually stopped.

When people decided, during this period, that they wanted to build along this shore south of Scripps Institution, they saw grass-covered, apparently stable cliffs and presumed it was safe. My warnings to the few people who asked me were disregarded and all went well until the

winter of 1977-78. Up until then even the University of California architects had begun to disbelieve the dangers of coastal retreat. Now those of you who live along the coast of southern California know what took place that winter. The rain fell and storm surf pounded the shore. Everyone started clamoring 'Save Our Cliffs.' Fabulous sums of money were invested, both private and public funds, to stop erosion in many areas. It is hard to comprehend why architects built right where well-known dangers existed. It is, in fact, almost criminal that large developers have sold bluff-edge property all along the coast north of San Diego, where studies can show that cliffs have retreated a foot or more per year, and that streets existing on the bluff in the late 19th Century have been wiped off the map.

My young associate, Gerald Kuhn, has made an exhaustive study of the records. Getting this information into the newspapers has made his life precarious. For a while he was receiving phone calls late at night threatening him if he did not stop his exposures. The 1977-78 winter helped prove his point, however, and seemed to arrest the worst opposition, some of which was coming from professors of geology in our neighboring colleges.

Near the end of the war Parker Trask and I had a good chance to observe what can happen during a powerful storm period. We had just measured some profiles along the base of the outer cliffs of Cape Cod when a severe storm of ^{gale:} hurricane proportions hit the area. At the time we were out in a yacht and just got into Woods Hole Harbor before the storm suddenly hit. Our anchors were useless against the howling wind

but under power we were able to tie up to a government mooring, renewing our lines from time to time as the wind howled across the harbor sometimes at speeds over 70 miles per hour. Rain swept across the boat with spray of such stinging force that we had trouble in all deck operations, but we stayed pretty dry in the cabin.

Near the end of the blow a Coast Guard launch came alongside and some of our more reluctant passengers hoped they would be taken ashore but no, the Army was calling my son Tom back to his duties: His leave had been cancelled.

When the wind abated, Parker and I went ashore and borrowed a Woods Hole car and worked our way up the arm of the cape over the storm-battered roads and reestablished our profiles, finding that many feet had been cut from the 100-foot alluvial cliffs during the storm.

Later, with various assistants, I visited beaches all along the coasts of the United States. Finally, many years later most of my results were incorporated into a book written with my former colleague from the University of Illinois, Harold Wanless, who had worked for a year with me, getting together his studies of air-photo compilations and including them with my beach study observations in book form.¹

As to the future of these coastal studies, I feel that it is in very good hands. I hope to help, so far as I am able, but Gerry Kuhn, as I mentioned before, is deeply involved in this work.

¹
Our Changing Coastlines, 1971. McGraw-Hill Co., New York, 579 pages
(F. P. Shepard and H. R. Wanless)

CHAPTER IX: A TSUNAMI INTERRUPTS MY FIRST POST-WAR VACATION

In memory of Dr. Gordon A. Macdonald^d, vulcanology professor at the University of Hawaii, who played such a large part in the investigation of the tsunami of April 1, 1946.

Dodging the Waves at Kawela Bay, Oahu

After the war years of intensive research on Navy problems with little time off for relaxation, we felt that I was due for a good month's vacation. This was really the first of what I call my writing vacations, as I was under contract with Harper Brothers for a textbook, Submarine Geology. So I gathered together reams of notes and many books, and Elizabeth and I set off for Hawaii where we planned to spend a month in the summer cottage of Professor Harold Palmer of the University of Hawaii, on the north coast of Oahu at Kawela Bay. The swimming was fine and I thought I could write uninterruptedly whenever I felt like it.

Our good friends the Palmers had the neatest little cottage you ever saw, with everything in its right place, and we were determined to keep it that way, but old man Neptune thought otherwise. After twelve days of delightful rest and considerable progress on the book in many odd hours, we went to bed and, as usual, slept like two logs. Early the next morning, April 1, 1946, we were awakened by what sounded like hundreds of engines blowing off steam. We looked out to find the ocean had risen to the top of the beach ridge in front of the house and was spilling over into the cane field. I grabbed my camera and ran to the lanai (as the front porch was known) where I could see the sea beginning to retreat down the slope. I shouted to Elizabeth, "Could this be a tsunami (tidal wave)?" She said that, "No -- in stormy conditions the sea sometimes comes up to the front porch, according to the Palmers." I thought to myself that the storm waves did not retreat that fast, but did not want to argue.

We donned sneakers and raincoats over our pajamas and rushed out, me still carrying my camera. I was disappointed that I did not get a photo of the high stand of the sea, thinking that the first wave would certainly be the highest. At that time it was not clear from the literature if this was the case or not.

Well, the sea withdrew and in my excitement I shot double exposures of fish jumping up and down on the bared reefs. I soon began to wonder if the first wave really was the highest, watching the build-up of water on the reef margin a few hundred feet out from shore. It got higher and higher and started to pour over the corals with a great breaker, moving rapidly toward us. Elizabeth ran to get behind the house but I felt fairly confident that it would not get higher this time than the first, and stood my ground for a few more seconds and got a pretty good shot of the breaker as it topped the horizon.

picture

"Maybe I'm wrong," I decided and raced back to join Elizabeth as the water swept over the place where I had been standing and smashed in the lanai of our house. We saw our refrigerator go sweeping past us and into the cane field. Looking toward the garage we saw our car was surrounded by water. Then, to our horror, we saw what had been the house next door to the right -- all that remained was a mass of kindling. Since the road was under water we were on a temporary island. The water soon retreated again and our only escape, so far as we knew, was along the 17-foot high beach ridge to the west where a trail led to the main highway. Hurrying along the ridge, we found some wet, bedraggled Hawaiian women in the wreckage of their camp, wringing their hands, at a loss for what to do. We persuaded them to follow us and we all raced as

fast as possible along the path through the sugar cane. We made it across to the road just ahead of the next wave. Still running we could hear the waves smashing into the cane field behind us. This wave seemed even larger than either of the first two.

We realized we were in pajamas, sneakers and short raincoats, and aside from my camera which was now out of film, we had nothing with us. We found quite a group of refugees on the road. One couple said they had been cooking breakfast when the second wave picked up their entire house and carried it gently for several hundred yards into the cane field, the stove still cooking all the while as if nothing was happening. One house was swept out into the bay but, fortunately, no one was in it.

After watching until maybe the eighth wave had come in, I decided it was time to go back to our house and see what could be rescued. One of the local people said he knew a path that would take me directly to where the Palmer cottage was located. I followed him and as we came close, I could see that at least the rear of the house was still standing. Suddenly another wave came roaring in, still larger than the others, and the house was surrounded by water. My guide and I had to run for a small ironwood tree behind the house and climb up, hanging on while we were shaken like rats by a terrier as the water rushed beneath us.

My enthusiasm for exploring the ruins was gone, and when the water had again receded we returned to the road with nothing to show for the venture. The inside of the house looked terribly damaged, but I could see that some of our clothes were apparently still on hangers in the closet, but hard to reach without ladders.

Getting back to the road, I found Elizabeth had made the acquaintance of just about the nicest people we have ever known, the Heberts. They took us to their home at nearby Kahuka, outfitted us with clothes and fed us. Elizabeth was amazed to hear me singing in the shower as I washed off the dirt from the cane fields. We experienced real Hawaiian hospitality from then on. A few days later, when the road was repaired and we got the car running, which was not badly damaged, we went to Honolulu to see our friends, the Eaton Magoons, who insisted we be their guests until we got straightened around.

In the meantime, back in La Jolla our son Tim thought we were among the victims, and the Sverdrups offered to adopt him. My manuscript, of course, was scattered throughout the cane fields and my books were swollen with water to many times their normal size. However, being young and enthusiastic, I thought, "Here is a chance to really find out what has happened in a tsunami of major proportions." I enlisted the help of my friend Gordon Macdonald of the U. S. Geological Survey and he contacted Doak Cox, a geologist with the Hawaiian Planters Association, who has later become an expert on tsunamis. The three of us began a tour of the islands.

Tour of the Hawaiian Islands Looking for Tsunami Damage and Wave Heights

Sverdrup, then director of Scripps, authorized my expenses from Scripps Institution and we made what was the first real attempt to cover an area carefully to see just what these waves, set up by fault action on the sea floor, could do upon arrival in a distant area. We started our study by investigating the island of Oahu (see map). We found little

damage on the Honolulu side; along some inlets the waves had swept up and damaged boats in the waterways. Pearl Harbor residents at first thought it was an April Fool's joke. The tsunami showed only a few inches on the tide gauges. However, as we worked our way along the southeast side, things were quite different. The coastal lowlands were more and more submerged by the waves. Roads were washed out and housing developments on the flats were damaged extensively. Just around Makapuu Point the sea rose to its greatest height found on the entire island, 44 feet, cutting a large notch into the sand dunes at that height. This was the side of the island where the waves came without interruption from their source in the Aleutian Trench, which we found out later.

One might expect to find the greatest height at Point Kahuka, in the middle of the north side of the island, with perhaps a continuous rise toward that point. However, that was not the case. Going west from the eastern point, the height actually decreased until at Kaneohe Bay, which is across the island from Honolulu, there were almost no waves at all. This could be explained by the wide coral reef which protects the shore at this point. As at Pearl Harbor, the people living inside this reef learned of the tsunami only from their radios. Farther west along the coast the coral reefs narrow, and the waves were progressively higher, reaching 30 feet at Point Kahuka, the northern point of the island. Then the reefs again become more of a factor and the waves lower, fortunately for us at Kawelo^a Bay. Continuing toward the western point we found a beautiful relationship between reef width and wave height. Getting near the point where the reef disappears completely the waves caused considerable damage to the highway and small settlements.

Around the corner to the west, wave heights continued to be high for a short distance, but damage to the coastal communities farther south was not great and occurred only where there were very low terraces.

On the island of Kauai, the northwestern-most island of the group, much the same pattern was observed. The north side of the island received most of the damage, although the places where high waves were observed were not heavily populated and most of the destruction was to vegetation. In some of these areas the water rose as much as 50 feet. The narrow coastal lowland west of Hanalei showed many places where the brush, consisting largely of pandanus was all ^wboiled over; many large blocks of coral were found well inland, some at the mountain wall. Along the north coast we found that the wave heights were well correlated with the submarine topography which consisted of high inside submarine ridges and low inside submarine canyons. This is also true of ordinary wind waves. The south side of the island had little damage as in Oahu, and also like Oahu, the waves rose surprisingly high in some places around the corner from the exposed north side.

The elongate island of Molokai showed further examples of the effect of coral reefs. The south side has extensive reefs, as well as protection by the shape of the island, and waves were consistently small, causing almost no damage. Much of the north shore is inaccessible, but where we did get information we found some great contrasts. The waves rose to a height of 53 feet just east of the Kalapaupa Peninsula where the leper colony was located, but at the outer end of this low peninsula the waves did not rise as high as they had during preceding winter storms.

We landed in a small plane at the edge of the peninsula and found logs pushed higher from the storm than from the much more recent tsunami, the latter being only about 6 feet. These two contrasting heights are within a mile of each other. The explanation is apparently that the tsunami, because of its long period, had no distance to build up on a shelf before encountering the steep edge of a recent volcano on the point, whereas the storm wave, having relatively short period, did not require any distance to build up height. Our landing was on a rolling dune surface much like a roller coaster, but without mishap. We were met by a jeep from the leper colony then still in existence, but now disestablished. It was distressing to see some of the victims of the disease, but we were told not to be worried by them nor to disturb them. They are now largely cured.

The location at the base of the great north escarpment is spectacular and I suppose will become a great tourist attraction now that they have a good landing field. The only other approach is a trail down the escarpment on the west side of the point.

The island of Maui, consisting as it does of an old volcano joined to a new one which is considered dormant and much larger than the old one, has a relatively broad lowland in between the two. On the north side of this lowland the city of Kahului and its adjoining Sprecklesville are located at a wave convergence for long period waves so that they were devastated by the tsunami in their lower portions. The harbor breakwater provided some protection for Kahului, but when the breakwater was partially destroyed water rose more than 20 feet into the streets. Beach houses all along the coast to the east suffered considerable damage with

waves rising as high as 28 feet above normal. Most of the other settlements on Maui are on the south side of the isthmus between the two volcanoes, and here the waves penetrated very little because of the various islands to the north and northwest that broke them up. A few low areas were slightly damaged. On the other hand, the long northeast coast around the base of Haleakala Volcano was much more exposed and wherever towns existed on the lowlands, particularly at the southeast side of the island, the waves rose and caused destruction to lowlying settlements, as in the vicinity of Hana.

The island of Hawaii suffered by far the greatest damage of the great waves from the tsunami, and so far as we could determine had the point of highest rise of the waves, 55 feet where, near the northeast end of the island a small town was obliterated. The natives saw the great waves engulfing their homes from their fields on the plateau directly above the site where, fortunately, they had all gone for early morning agricultural chores. However, the great loss of life and property was much farther east along the island at the city of Hilo where the waves mostly did not rise more than 20 feet, but destroyed the breakwater and swept over the lowland wrecking most of the buildings along the waterfront and numerous low-lying homes. Great waves swept up the various river valleys that are located there and destroyed all the bridges. Most of the 150 drownings occurred at Hilo, and many of them were the result of the citizens' rushing out onto the exposed reef when the water withdrew before the first great wave, exposing fish on the reef in the harbor. Some good swimmers actually rode the wave in and were saved.

A curious feature of this destruction at Hilo came from a study ^{by} of psychologists. In 1960 Hilo was again devastated by a tsunami coming, in this case, from South America. Survivors were asked to fill out questionnaires which revealed that the citizens paid little attention to the tidal wave warning that sounded before the second onset of large waves. Those who had experienced the first waves paid less attention to the warning sirens than those who had not. Furthermore, education showed an inverse relation: Those with higher education were less inclined to heed the warning than those with only elementary education.

One of the more mystifying results of the waves that hit the island of Hawaii was the arrival of some waves that caused a small amount of damage on the protected west coast many hours after the other destructive waves. We learned about these from several villages on the Kona Coast. Waves came into the piers late at night, whereas the main destructive waves were in the early morning. There seems little doubt but that this is a case of double reflection of the long period waves off the Asiatic or Ocean Island coasts of Asia and Oceania. For some reason these reflected waves became converged on the Kona Coast at certain points, despite their tremendous voyage which can be ^{reckoned} reckoned by considering they were advancing about 450 miles per hour for some 34 hours, making about 15,000 miles. Thus, there are many things still to be learned about tsunamis. Why, for example, are waves from an Alaskan earthquake like that of 1964, which destroyed much of the coastal area around Anchorage, Alaska, capable of advancing diagonally down the west coast of North America and causing great destruction at Crescent City in northern California, whereas other great earthquakes along the Alaskan

coast had no effect on the towns along the northern California and Oregon coast? On the other hand, the 1964 earthquake caused almost no damage to Hawaii in contrast to several Alaskan earthquakes, such as the one occurring April 1, 1946, that was disastrous to Hawaii.

Our studies of the island coasts and the heights of the waves seem to establish several results which may be of importance in connection with planning for future destructive waves:

1. We found that there was ample evidence that destructive waves are frequently not at the very beginning of the tsunami, and may occur as late as the eighth wave or even much later, under special circumstances.

2. We found that loci of high waves are likely to be just around the corner from the exposed side of an island.

3. We found that coral reefs are a great protection from the effects of the waves, and that often the height varies inversely with the width of the reef that lies in front of an area.

4. We found some correlation with the submarine topography such as submarine canyons and ridges, with waves increasing in height inside submerged ridges and decreasing inside submarine canyons.

5. We found some evidence that waves may be important inside what appear to be protected areas because of the reflection of the waves from submerged escarpments.

Another interesting result of this prolonged stay in Hawaii came about through our visit with the Magoons after the tsunami. Since it was necessary for Mrs. Magoon to be hospitalized for quite a long period, Elizabeth somewhat took over the care of their young son Orville, and I

had a good opportunity to talk with him extensively. He became much interested in my work and our contact apparently helped shape his future career. Some years later, when he finished his course at Yale, he decided to go into studies of beach and coastal erosion and got an appointment in the civilian portion of the Beach Erosion Board of the U. S. Army Corps of Engineers. In this work he developed many original ideas which were at first scorned by the army, but later their importance was recognized. He is now their principal scientist in the California coastal area and has expressed appreciation of the work being done by my associate Gerry Kuhn, and has been of great help to him.

CHAPTER X: A MAJOR PROJECT FROM THE AMERICAN PETROLEUM INSTITUTE

Dedicated to Dr. Parke A. Dickey whose stand in defense of my work in API 51, against the intolerance of a chief scientist of an allied company, resulted in the loss of his own position as a chief scientist, although it resulted in a much pleasanter life as a widely known geology professor at Tulsa University.

In 1950 a large sum of money once again seemed headed my way, offering a wonderful opportunity to conduct research, and this time with ample funds. Instead of \$10,000 which seemed so large in 1937, the American Petroleum Institute was talking about grants of over \$100,000 a year that might continue for many years. With the help of my new colleague at Scripps Institution, Fred Phleger, I prepared a project for a study of the sediments of the coastal and continental shelf areas of the northwest Gulf of Mexico, covering an area where sediments were of great interest to the major oil companies. This included the Mississippi Delta and even a small project in the Florida Keys. Our Scripps Institution project had severe competition from Louisiana State University with its rapidly developing Coastal Studies Institute under the great geologist and geographer, Richard J. Russell. After a considerable debate among supporting companies we managed somehow to get the nod, though several powerful members of the API committees were former LSU affiliates and we started out with several strikes against us. There began in 1951 a period in my life that I shudder to contemplate. I was a bird in a gilded cage. As Elizabeth put it, "Your disposition was awful."

Things started out rather pleasantly when my old friend Ben Cox of Gulf Petroleum arranged for us to view the Gulf Coast in a Gulf Oil Company low-flying plane. We got a bird's eye view of the coast; it looks quite different from the air. Next, gathering a group of young geologists, we set to work centered mainly in two areas: Rockport, Texas,

near Corpus Christi, and the lower Mississippi Delta. I was fortunate enough to secure the assistance of David G. Moore for the Rockport area and Philip C. Scruton for the Mississippi Delta, along with Joseph R. Curray in starting a program for the study of the continental shelf, and later Eugene Rusnak for the Laguna Madre area. All four of these young geology graduate students developed rapidly, just as had happened with Emery and Dietz, whom I had with me during the Penrose grant for canyon studies. Although Phil Scruton died unfortunately a few years later, he had gone far in his delta studies; Rusnak was forced into an early retirement due to ill health after a fine early career. The others are well-known to geologists for their fine accomplishments in the marine geology field. The small project in the Keys of Florida was the beginning of work in the carbonate field for Robert Ginsburg, now a shining light in this subject.

I spent a month of the first summer with Dave Moore and Robert M. Norris in the Rockport area where we went out in small boats in the bays with local boatmen. They said they knew every oyster reef in each bay; I guess they should have; we hit enough of them in our traverses of the muddy water. We were given facilities at the Texas Fish and Game laboratory at Rockport which was a great help in working up our results. For analysis of the type required in the biology field I acquired the assistance of Robert H. Parker, a microbiologist, and we found he knew all the names of the bivalves and was a great help to us. Fred Phleger and Francis Parker of Phleger's Foraminiferal Laboratory took charge of the studies of microorganisms. I enlisted Ralph Grim, a well-known expert in clays from the University of Illinois to study our clay samples.

An amusing aspect of this period was the appearance on the scene of the former director of the Rockport lab who was the sworn enemy of the current director who had followed him in the post. We expected to see them pull out pistols and fight to the death, but it somehow all boiled down to words. Each one told us how awful the other guy was.

We found we could get some cooperation from a geologist friend, Perry Bass, whose uncle, a wealthy oilman had a famous ranch on nearby St. Joseph Island. Perry was vacationing there and invited us over. After a fabulous lunch and a tour of one of the world's greatest collections of paintings by Charles M. Russell in his uncle's gallery, Perry loaned us a couple of jeeps so we could explore the barrier island, sweeping over the dunes and coasting down their steep frontal slopes as if on sleds. Of course we did get one jeep stuck in the muddy marsh on the inside of the island. We could not get it out and had to go back to the ranch house for help -- Perry said it was par for the course.

After a month of working on the study I left my field party for a tour of some petroleum laboratories where various members of my large API committee were located, to tell them of our preliminary results. I guess I should have smelled a rat here, but as usual was a complete innocent, feeling sure that everyone would be enthusiastic about our findings. There did seem to be a coolness on the part of a certain important geologist and a lot of reticence from another. I did realize I was invading territory where I had little previous experience, and that some of the company geologists occupied positions which gave them an aura like that of T. C. Chamberlin in the Geology Department at the University of Chicago.

Finally this tour of the laboratories ended and I again breathed the cool air of southern coastal California. Here I had to build up the laboratory analysis personnel and equipment, including chemistry and grain-size analysis. I found a clever Chinese scientist, Dr. George Bien, who had escaped from Communist China along with his wife, a medical doctor. He fitted into the chemical phase of the study.

Meeting with my API committee, I really encountered some stone walls. As soon as I presented ideas that did not wholeheartedly support the thinking of the alumni of Louisiana State University who were now big shots in the oil industry, I was in trouble. They knew the answers they wanted, and they wanted us to use their methods to find supporting evidence for their ideas. I suggested that a method of determining the environment in which ancient sediments were deposited, called "coarse fraction analysis" was more successful than those being employed at that time, but they knew better. I proposed that we obtain a series of recent sediment samples, locality unknown, so that each group could diagnose the present-day environments and thus see which method could best interpret the samples, ^{but} our oil company opponents scorned the idea as "kid games."

Regarding our work in the Mississippi Delta we heard remarks such as, "What is a rank amateur trying to tell us about this area where we have hundreds of bore holes? We know that sand extends well down the delta-front slopes." I tried to show them that Phil Scruton's samples on the delta front showed otherwise, but they knew all about it. There was no doubt that one of them could shout louder than I could, and talk with a more authoritative tone. When I produced maps to prove our

contention, they just changed the subject. I must confess that Scruton had a more pleasant way of developing some of these points than I did, and stepped much more gently on their toes. I should have learned that method early in my career.

I remember taking a sizable group of our committee out on the Lower Mississippi Delta in a boat, to point out some of the things we had been finding. At first it was a beautiful day and everyone was interested, but just as we were getting to a critical area, clouds swirled up and a terrific "norther" hit us. The entire committee retired to the small cabin and we worked alone on deck to obtain the necessary proof for our contention. Few were interested in any more science on that stormy day.

Another somewhat trying experience occurred during work on this project. I joined Gene Rusnak for a trip along the then quite deserted Padre Island, in southernmost Texas. We were fortunate to borrow a jeep from the State Biological Laboratory located on Aransas Pass, the only entrance to the waterways around Corpus Christi. We were told that there was an operation two thirds of the way down the island, where the state was cutting a navigable pass through to Laguna Madre. We had enough gas to make the trip down, and were counting on getting more gas at the work camp. We started along the beach which included a small section of Mustang Island which is virtually connected to the 100-mile long Padre Island farther south. We wanted particularly to cross the dunes of Padre Island at several points to have a look at the mud flats of Laguna Madre. We crossed the arid Padre Island at two or three places and got a fine look at the largely evaporated lagoon.

Imagine our consternation when we reached the place where the new pass was being dug and found it completely deserted. We had not seen a

soul, in fact, for almost a hundred miles along the traverse. We hadn't even seen many jeep tracks. We tried to economize on gas but got only to within about 16 miles of the road at the south end of the island when our last drop was gone. Our food and water supply were also getting low.

After some debate we decided that Gene, being the considerably younger of the two of us, would walk on to get help. I gave him most of the water and he set off. It was well along in the afternoon and very hot. I sat in the partial shelter of the jeep keeping a sharp look out for traffic. Time moved slowly, but it finally got dark and I could hear coyotes and other animals stirring about; it sure got lonesome out there. I slept rather fitfully, waking every once in a while thinking I heard a jeep. At about 6:30 the next morning I really did hear one, and ran out to flag it down in case it wasn't Gene. It proved to be two fishermen and, to my joy, they had a couple of cans of gas tied to the side. I told them my woebegone story and they said they had not seen Gene on their way down. I began to worry again. They rather grudgingly gave me enough gas to go the 16 miles to the road, and I was a most grateful soul, I assure you, particularly when the jeep started up without any trouble.

I drove along the beach and came to a road with a sign pointing the way to the Coast Guard Station. Just then Gene appeared in the Coast Guard jeep. It seems he had gone up into the dunes late in the evening to sleep, and the fishermen went by him in the night. He had then walked on to the Coast Guard Station, very thirsty and hungry. It was a grand and glorious feeling for both of us to have our adventure come to a happy end, and we ate and drank to our hearts' content.

My work on the API project took me away from the parts of marine geology that I loved best; submarine canyons. However, when I started looking at charts of the area around the Mississippi Delta, I was surprised to see that where soundings were numerous, off the three mouths (called "passes") of the river, there were many valley-like features on the submarine slopes. I contoured these carefully from the original Coast and Geodetic Survey survey sheets and found that they were well-developed only off each active pass of the delta, dying out in between. This gave me an idea. Joining Phil Scruton, I decided to survey some of these valleys. Using methods learned from the Coast and Geodetic Survey officers some years previously, we obtained some accurate results, and when I compared them with the surveys made earlier, I found to my great excitement that the valleys had changed position and depth remarkably. (continued on page 102)

Some had filled and other new ones had formed. I wrote a paper suggesting that underwater slides were the cause, occurring from time to time making the valleys, and then the sediments from the river begin to fill them in. "Impossible," said the authorities on the delta. "The slopes are only half a degree. No slides occur on such slopes." Fortunately my friend Professor Karl Terzaghi of Massachusetts Institute of Technology, the great authority on slope stabilities, took up the cudgels and said that water-saturated muds off the Mississippi could easily slide on such slopes. Well, they still would not believe me. Now, many years later, James Coleman who was directing the Coastal Studies Institute of Louisiana State University has made extensive studies and found indisputable evidence that slides and slump topography are controlling this whole slope. The oil companies all know now that this is the case, as they are constantly having trouble with their structures off the delta, with slumping on slopes far gentler than those I talked about in my paper. Sometimes you really get your ideas supported in a big way, but it did not help at that time and my name was getting blacker and blacker, kind of like Truman when he had the guts to fire General MacArthur.

After several really awful experiences with the API Project I decided to persuade someone with a background in the oil companies to join me in my efforts. After trying several retired high-ranking geologists from the oil industry who were somewhat interested, but not enough to take the job, I heard about T. J. van Andel, a whiz kid from Holland who was then working with Shell Oil Company. He joined up with enthusiasm. When van Andel took over as associate director, the administrative part of the

project was largely lifted from my shoulders. In fact, I began to quite enjoy life again, for a change.

We did have one more knock-down, drag-out fight at a committee meeting in which our Scripps director, Roger Revelle, was present. Shortly after that, as Christmas was approaching, I awoke one night with an inspiration. I decided to write all the committee members a Christmas card in which I would depict an API Project 51 committee meeting as a one-act play. I reproduce this below. It gave me such a lift to get it off my chest that I really did enjoy the next couple of years of the Gulf of Mexico project until it ended in 1957. Roger Revelle said, when shown the skit, "Swell, but you shouldn't send that out!" "The hell I shouldn't," I replied -- and did.

Most of the committee appreciated the blurb and got a good laugh. There were, of course, some fireworks, as I learned later, but from then on, the meetings were very peaceful.

(Slobbovian for "Let's get them university buzz")

A comedy (of errors) with only one axe.

Anon-A-Mouse

Scene laid in a courtroom with a guillotine looming large in the background. As the curtain rises the genial, smiling judge looks around with some apprehension at the dark glowering looks of the gathering. The Senior Scientist from the Great Delta rises to his full length and smiles briefly while a battery of cameras are trained on him. After the applause subsides, he proceeds to deliver a carefully prepared oration.

Sr. Sci. Gt. Del.: "Gentlemen; my company lawyers have been busily engaged for the past few years in poring over the records of this project. In my Humble opinion they have indeed discovered some amazing discrepancies; thus, a letter written on April 1, 19__ from the president of the university says, and I quote: 'The learned scientists of our institution will henceforth devote 24 hours daily to the services of the great society which has honored us with a grant.' And yet I am forced to report that my scouts in that wild western area have informed me that on January 1, 19__ three members of the faculty of said university were detected catching catfish."

Loud applause follows and the Junior Scientist from the Great Delta jumps to his feet and, wringing the hand of his colleague, demands the floor.

Jr. Sci. Gt. Del.: "I concur entirely in this indictment; in fact, I myself observed some of the culprits in a lowly dive in the French Quarter."

The defendant then staggers to his feet and after looking around vainly for a nearby exit, says in a faltering voice:-

Defendant: "Gentlemen; this is terrible, but as the fellow said when reminded by his mistress that he had promised to marry her, 'During a campaign one is expected to promise a little more than he later fulfills'."

Loud groans and the victim sinks back on his hard seat.

Sr. Sci. Gt. Del.: "Now, gentlemen, to continue with the prosecution. I understand that the culprit has been drilling holes into the sacred soil of Texas and overlooking the fact that my colleagues and I have established (after drilling so many holes that the coastal area now looks like Swiss cheese) that the Modern is limited to 24 feet and 7 inches. After all this, they had the effrontery to drill to several times that depth and in their ignorance failed to perceive that they had passed that invisible boundary between the Modern and the Recent."

Jr. Sci. Gt. Del.: "I could not have expressed the difference between the Modern and Recent better myself."

Defendant: "But Sirs, if I may presume to say a word, my untrained eyes led me to believe the sediments were all bay deposits to these great depths."

^{1/} Any resemblance between the characters here portrayed and living individuals is purely intentional, absit invidia.

Sr. Sci. Gt. Del.: "Young man, let me see those profiles."

Some gaudily-colored illustrations are then produced.

Sr. Sci. Gt. Del.: "Ah! You see, gentlemen, a bed of succulent oysters was encountered in this hole at 35 feet (practically the same as 24 feet 7 inches). What self-respecting oyster would survive the beginning of the Modern?"

Defendant: "But I thought there were some oysters still living."

Sr. Sci. Gt. Del.: "You see, gentlemen, how he entirely missed the significant point I was making."

The Senior Scientist from the (ex) smoky city now bestirs himself and gradually works his way to a standing position. After assuring himself that all are listening intently, he proceeds.

Sr. Sci. Sm. City: "I perceive there is a great Gulf between my thinking and that of my confreres from the great delta. I hope they realize that we are dealing here with megacycles, microcycles, and psychocycles. This point will of course be obvious to all of you gentlemen, so let me proceed. (He grabs a piece of chalk and sketches rapidly on a black-board.) Now, let us assume that the aborigines attacked the oyster bed at A in 5234 B.C. and at B in 1327 BC, whereas at C the oysters lived happily until the coming of Columbus. Now then, would the Modern end at A, at B, or at C?"

Sr. Sci. Gr. Del.: "Your Honor, I consider this statement incompetent, irrelevant, and prejudicial to company morale. I move it be stricken from the record, or at any rate, let's change the subject."

The Senior Scientist from the Great Dust Bowl was then recognized.

Sr. Sci. Dust Bowl: "Gentlemen, I fail to see why the inquisition is overlooking an important point which my company would never tolerate. In a meeting held right in the heart of that den of iniquity called La Hoy Ja, a suave scientist opened a secret panel and produced a new map at which his colleagues stared in amazement. They thought at first that they saw a contour line until the scientist explained that this was only a trail left by a foram which had walked across the map while the ink was still wet. It was obviously the duty of those professors to have scouts in the other laboratories who would report any major developments of this nature. You see, gentlemen, we must organize these scatter-brained scientists."

Judge: "The defendant has now heard the charges and I am sure will proceed to defend himself nobly."

Defendant: "On the advice of my tall counsellor, who has just removed his feet from the toes of three junior scientists, I prefer to invoke the Fifth Amendment and hereby wish you all a

MERRY CHRISTMAS

and

HAPPY NEW YEAR

After about seven years I got everything together from this project and into a book with the active help of Jerry van Andel and Fred Phleger.²

Looking back on the project I guess it was worth the effort despite all the agony. In addition to starting some top-notch people off in marine geology I did educate myself about sediments and sedimentation in which I was rather misinformed, and I did start to use some methods which ~~are~~ ^{have been} used considerably in the following years. I got a real feeling about the relation of sediments to environments and tried to show simple methods of testing them. The chance to study the Mississippi Delta and the seaward slopes was perhaps the most interesting from my viewpoint, and more than twenty years later I am finding a chance to apply some of the things learned from that work to my submarine canyon studies.

3

Recent Sediment, Northwest Gulf of Mexico, 1960. A Symposium Summarizing the Results of Work Carried on in Project 51 of the American Petroleum Institute 1951-58, F. P. Shepard, F. B. Phleger and T. J. van Andel, eds., The American Association of Petroleum Geologists, Tulsa, OK, 394 pp.

✓
Phleger
note: no
period
after B.

CHAPTER XI: TOUR DE MONDE

*In memory of Jawaharlal Nehru, the greatest of Indian political leaders.
Meeting this great leader and hearing his remarkable address to the
All India Science Congress inspired me for the rest of my life.*

Thailand Pacific Science Congress and Ankor

It sounds bad, but if you circumnavigate the globe going westward, the sun rises and sets one less day for you, and the only way to get that day back is to fly east around the globe, and who wants to do that? Anyway, partly to help recover from API 51, I decided to obtain a no-cost military flight such as were available to those of us who received support for our investigations from the Office of Naval Research (ONR). There was a Pacific Science Congress in Bangkok, and I had various invitations from Japanese and Indian geologists to lecture at their institutions along the way. Elizabeth had to fly commercial, so I met her at various places.

Setting off for Tokyo, I found someone in ONR had given me VIP status and so I traveled with the generals and admirals. I never did find out why. However, it was most pleasant and when we landed in Hawaii at midnight, the VIP's were whisked off to fancy quarters at Hickham Field for a few hours rest while the rest of the poor scientists on the same plane had to sit in the airport waiting for the flight to continue. Also, I amazed and impressed my former student from Japan who met me, getting off the plane in Tokyo with the generals and admirals. He drove me to the hotel where I met Elizabeth. It seems that Elizabeth had originally intended to stay elsewhere on the recommendation of a colleague at Scripps, but our friend, Professor Miyaki, said it was actually a fancy house of ill repute (unknown to our friend at Scripps). Professor Miyaki came to her rescue and put her in the respectable hotel where I met her.

The Japanese were wonderful to us during our short visit. The owner of the large hotel at Nikko had a son who was one of my former students in submarine geology. He sent us railroad tickets to go to Nikko, including a ticket for our Japanese friend Professor Ninno. We went to Nikko through forests of maples bedecked in magnificent fall colors. We had a wonderful lunch at the Nikko hotel and were provided with a guide and car to take us to see the remarkable temples and scenery: beautiful lakes and vast tree-covered slopes with fall foliage at its very best at higher elevations. We then met our host who took us through his large garden -- the height of perfection.

Professor Mi^yaki arranged for us to be met at Kyoto and shown around the wonderful temples of that area. The poor young professor came up from Kobe on the train just to take us to our hotel, a genuine Japanese inn, and after refusing our offer for dinner, he returned to his home in Kobe for the night, and came back early the next morning to continue guiding us. We loved the Japanese inn where we were served supper sitting on pillows around an hibachi in our bedroom, wearing kimonos and eating with chopsticks. We had a soak together in a big wooden tub, though the water almost boiled me to death. Japanese girls massaged our shoulders and provided us with big wrap-around towels and new kimonos and we slept on mats on the floor, completely relaxed.

We spent the next day touring some of the finest temples and castles in Japan, with wild deer roaming the grounds. Later at Kobe we met our local host's delightful family and were much impressed with their bright son who was interested in coming to the University of California when he finished his early schooling in Kobe. I was glad to sponsor his

application and he was admitted. Then on to more temples and shrines in Nara before flying back to Tokyo. Our flight was spectacular. There were still American pilots flying Japanese planes in those days, and ours, on hearing I was a geologist, asked if I would like to sit in the co-pilot's seat. He then proceeded to circle the brilliantly clear Mt. Fujiyama and next veered off to visit O'Shima Island in Sagami Bay where a volcano was in eruption. I never again had such a flight.

A few days later we left Tokyo, with much regret, bound for the Pacific Science Congress in Bangkok. At the Congress we were among the few fortunates who were not put up in a fancy new hotel, but instead went to the Oriental, right on the river with a balcony looking down on the magic scene of the boats of every type that weave in and out on the busy river. We could watch the pageant of life passing constantly below us. We were somewhat horrified to see people dipping toothbrushes into the filthy water of the river to clean their teeth. Survival of the fittest is certainly the rule there. Many people live on the side canals, or klongs, as we saw on boat tours between Congress sessions. What we were most impressed with was the happiness and good nature of the native people. No one seemed to be angry; maybe it was the tuneful quality of their voices. In the city streets and in the markets, no one ever hurried their pace. We decided, in view of this, that the Buddhist religion must be pretty good. Perhaps we should support Buddhist missionaries to convert the Christians. What a contrast to the angry voices that one hears in the crowded streets of Christian cities. I wonder if we received a correct interpretation of the feelings of the people in Bangkok, who surely must be very poor, at least by our standards.

After the Bangkok Congress I went out with a small ship of the Thai Navy under the command of a former student, Commander . . Penyapol, who had spent two years at Scripps Institution. Another guest, an Australian oceanographer, and I had such good treatment that we hated to complain, but unfortunately their Navy thought we would not like the delicious food served to the officers, and instead cooked us what they thought was western food; it was pretty awful. We finally got up the nerve to ask if we could share their food, and that worked out fine. I might add that the food that the sailors got (which cost about six cents per day) looked terrible; one big bowl. Anyway, we got along just fine on the officers' food but when we stopped at a port and I foolishly partook of some sweet at a restaurant, I got a bad case of diarrhea. Everyone was so sympathetic, they seemed to be suffering with me in their anguish that a guest should be sick. What a contrast to the way that the crew would have treated a guest with the same problem on an American Navy ship. Happily, I had a rapid recovery after visiting a Seventh Day Adventist hospital in Bangkok and procuring the right pills, which cost 25¢.

One of the high points of our entire circumnavigation was the visit we made to Cambodia to see the ruins of Angkor, now in considerable jeopardy as is the whole population of the country, facing starvation and annihilation by invading armies. We were thrilled with the great carved stone galleries of the ruins, and the walls rising right out of the jungle, still partially covered with tropical growth. What will happen to this greatest of all ruins?

Raft Trip in Northern Thailand [by Elizabeth]

After the International Pacific Science Congress at Bangkok a raft trip was offered to a limited number of scientists. As Fran had gone to sea in a Thai Navy ship to do some oceanographic work, I was able to take his place. I left the Oriental Hotel at 5:00 in the morning wearing Fran's trousers (I had not expected to need slacks as the Thai women do not wear them, and I had none with me), and carrying my belongings -- clothes and a few snacks -- in a string bag. We flew up to Chiang Mai, one of the old capital cities, about a 4-hour flight, passing over several cities we had already visited on field trips. There were first many miles of rice paddies; then beautiful wooded mountains with the teak trees in bloom. We flew low through a pass to reach a high plateau. Here we landed, to be greeted by cool refreshing mountain air, and the mayor. After dropping our gear at the Terminus Hotel, a rough inn, we paid our compliments to the governor who gave us soda water to drink as we sat around the walls of the room on straight-backed chairs.

In the afternoon we visited a weaving factory where the beautiful Thai silk is made. Their looms are very much like my Swedish one, except the shuttle is thrown by pulley, and they keep the cross in the warp between the treadles and the back beam. The warping and dressing of the loom is done exactly as I do it. Through sign language I made them understand that I too was a weaver, and showed them how to tie a weaver's knot and splice. They found the whole process most amazing and I was touched by their humble thanks.

As we drove through their open country the carts we passed were different from any I had ever seen, two-wheeled and low, always with a

flower design, much like the Pennsylvania Dutch, and an elephant design on the back. Water buffalo, with the usual white birds on their backs, were tethered by a line attached to a long pole slanting up in the air. The foliage was exotic and included all hues of bouganvillea; teak and lichi trees. The people were more small-boned and graceful than the population of Bangkok, with supple hands and feet, leaner and more sinewy, and with more slanting eyes and yellower skin.

We were driven up a mountain to see the geology, and the Thais always throw in an ancient wall or temple for good measure, as they are proud of their history and Buddhism. I must say that they live their religion -- quiet, gentle, relaxed, and always considerate. I never saw a Thai excited or discourteous or in a hurry.

Before dinner that night we were entertained, in our outing clothes, as they were all we had, at cocktails (the real thing) by the mayor and his wife of royal family. The estate was on the river with a guest house and garden as elegant as an American house. They made us feel at home in our field clothes even though they were in beautiful formal gowns. Each of the elegant women had jobs during the day doing public health work or teaching to better their community.

The next morning we embarked on our trip by bus to the falls of the river. The bus trip was slow torture. The roads were rough and the bus had no springs; the seat no upholstering - just bare boards - and we were crowded because of the low ceilings, as the Thais are such a small people. I am convinced the drivers are jet pilots on vacation. One bus followed us so closely that you could practically touch it, and when they

stopped suddenly (all movements were sudden), the busses actually did touch. Each time we would brace ourselves and cover our ears waiting for the crash, which never came. The driver thought it was great fun to scare us.

About four o'clock, after a day that seemed like a week to us, we reached the river and the five waiting rafts. We expected the trip to be primitive, but were not prepared for our rustic homes for the next six days. The rafts were made of large bamboo poles about 6 inches in diameter, bound together to form a floor 12 feet wide and 30 feet long, floating with 1 foot clearance. Six inches above this was a little thatched hut of bamboo equipped with four air mattresses and comforters, a tray of four glasses with jars of cold water and soda water, a thermos of hot water with Nescafe, canned cream and sugar, and four cups and saucers. The john was a little side piazza, also thatched, with toilet paper on a pole in the air. When in use the occupant was visible from the shoulders up, so at no time would you miss the view.

The four women were assigned raft number one: myself, two Thai girls and Helen Foster, ^{h.c.} A U. S. Geological Survey scientist who had been in Japan for seven years. She was a bundle of energy, even worse than Fran, but she, along with the rest of the scientists, soon fell under the spell of the river and lounged back on her air mattress, as we all did, using the folded mattress for a chair by day, to watch the ever-changing scenery. The two young Thai girls helped with the cooking, but didn't speak English, and neither Helen nor I could speak Thai. But with sign language we got along fine, with much giggling by the Thais.

We hung our belongings on the rafters and later, when the raft was awash going through the rapids, we found this a good precaution. Each

raft had two boatmen, one fore and one aft, with long poles. It was impossible to tell their ages, but they were sinewy coolies, jacketed and wearing the usual lampshade-like hats. Our front boatman had a serious face which would light in a beaming smile unexpectedly. In general we floated at the speed of the river, two miles an hour, going 80 miles in five days. When we came to the rapids the boatmen pulled in with a straw rake to avoid rocks, and when a wave swept the raft we clung to the rafters to keep our feet dry. Our boatmen stopped the raft for meals, allowing us to stretch and compare notes with our companions on the other rafts. At night we tied up to the bank. We usually rose at dawn, partly because of the cold and hard beds, but mostly because the boatmen who slept ashore awakened us when they brought their gear to the raft to stow it. We took a quick wash with some of our precious clean water, hoping to have a swim later. We didn't swim because the river was the color of cafe au lait and might have changed our complexions as well as threatened us with unknown disease. We decided to use the soda water to brush our teeth as the so-called water purification only removed the sediment from the river water. We made our coffee in the hut with Nescafe and went ashore to huddle around the cooking fire and eat bacon and eggs. At the sound of the gong we quickly took our places on the rafts; who would want to get left in the wilderness? Our boatmen with much calling back and forth, pushed off and we floated back into the current.

At first the river was wide, with rice paddies and native villages on the banks. Every native came out to look with curiosity and amusement at the rafts, calling back and forth to our boatmen who were probably

telling them about these strange people who were having such fun on this ridiculous trip. Later in the journey we came to a 1000-foot high limestone cliff with stalactites, caves with shrines, teak trees in bloom, and many brightly colored birds (80 species seen by our bird man). There were white monkeys chattering and jumping from branch to branch, almost missing like circus clowns; elephants moved teak logs which had jammed the river. We saw a huge 180-lb turtle being cut up, and a 15-foot python skin spread to dry. The only other wildlife was a 2-foot long water snake which invaded the bed of our most obnoxious guest -- the type of person who always had to be first -- had his two eggs at breakfast before everyone else had one; demanded the impossible from our Thai leader who countered tactfully but with humor, and considered us ignorant because we didn't speak his language.

We saw one village which had been largely depopulated by malaria, smallpox and cholera, and the few people we saw looked none too healthy.

We had good meals of soup, fresh vegetables carried on the cook raft, chickens which were carried live, as well as a pig in a pen which was later roasted in banana leaves. There were fresh oranges, bananas, grapefruit, and always rice, ^cooked in a variety of ways -- plain boiled, curried, or roasted in hollow bamboo trunks. Before lunch, as the Thai cooks prepared the meal on the bank we flexed our cramped muscles, exchanged experiences with the other raft members, and tried to assist the cooks who, with giggles, scorned our help, thinking no doubt that we were not capable.

At dinner time (we stopped about 5 o'clock) we freshened up with some of our precious water on the raft, but couldn't change our clothes as we had no changes. We would have a drink of rice whiskey with toasts, and proceed to our formal board - a sheet of plywood on bamboo poles. We swooped down like a bunch of vultures and cleaned up the food, glad to stand after sitting cramped all day on the raft. We were held so spellbound by the panoramic sights as we floated by, peering into the jungle, that we didn't even take time to stretch our limbs.

Our rafts changed places in line from time to time, staying close, spreading out a short distance. In passing there was much exchange of greetings and joking, and we even changed places on the rafts and had tea parties with our snacks, and there was competition to offer the most enticing.

After the first day we saw no permanent villages, just fishermen's villages and teak camps with elephants moving the logs. The only way to reach these places was by river, so it was no wonder that they stared at us. We gave them medicines and odds and ends of clothes and food, since we had the feeling that money wouldn't do them much good.

One morning a fire on the cook raft spread to our raft, I was more distressed at the thought of losing my halizone pills to purify water (used even in tea and coffee) and my malaria medicine than my money and passport. The Thais, with unbelievable dashing about, put it out with sand from the shore, for there were no fire extinguishers. ✓

The last day, after four days of various speeds, some slow and others short and swift, we went around a bend too close to the overgrown bank and our john was almost scraped off by an overhanging tree. We

began to speculate on the estimated time of arrival at the dam which was under construction, our destination, and to look forward to a bath and room at the government guest house. In spite of all the able geologists who figured where we were on the map, I won the pool with much joking, and they claimed that our boatmen held us back to make the finish line on the nose of my estimate. There was much excited Thai talk to find a place to tie up near the guest house, for they couldn't find the guest house, because it hadn't yet been built. So, another night on the raft. All but our three most difficult companions were reconciled to another night aboard.

After a fancy dinner ashore given by engineers building the dam, I was presented with the pool winnings and had a chance to thank our Thai hosts for their care of us -- their foreign guests old and young, famous and me, just a geologist's wife: six Americans, and I was proud of them all for their tact and adaptability, two Malayans, one jolly Englishman, two Frenchmen, one Japanese, one New Zealander, and six Thais. We all regretted the end of our trip by river as we went back by bus to our various accommodations, talking of our unusual expedition.

[back to F.P.S.]

India and Pakistan

Moving on to Burma we saw more old temples, and I was beginning to be anxious to get down to doing something besides being a tourist. We flew to Calcutta where we were put up in the palatial Great Eastern Hotel, right next to a quarter with the most abject poverty one can imagine. Thousands of people literally live on the streets that flank one side of this grand hotel where cocktails are served with orchids on the side. At night from beautifully appointed rooms you could hear people

coughing with a shuddering, reverberating noise. It seemed to be wave after wave of coughing all through the night. By day these people relieved their bladders and defecated in the street gutters. Wherever we went we were surrounded by pitiful beggars. Walking in the park we saw hundreds of prone bodies and wondered how many of them were corpses. Presently a truck would come by and men picked up the dead of the past night and carted them off. We were so depressed by this, and knew little that we could do about it, that it was a great relief to get on the train and head on for Waltair where I was to give some lectures to geology students at Andhra University.

Here our stay was enjoyable. We had quarters in a small apartment, and an Indian servant who had previously cared for our friends, Eugene LaFond and his family, during their year at the university. His name was Thomas, and he knew just what we wanted to eat, and was kindness itself, fulfilling our every wish. There was a sweet expression on his face that we have seen only among certain Hindus who seem to love to serve. The university staff was also very friendly and considerate to us.

I did wonder if the students were getting much out of my lectures. They listened but did not take many notes. At any rate, when I left they presented me with a beautiful scroll in a carved ivory frame, to express their gratitude, and I still have this among my treasures in my office at Scripps Institution.

[By Elizabeth]

From our balcony at Andhra University, in a hammock and a strong easy chair, we watched the town go by. Women hurried past with heavy

loads of fish on their heads. They were hurrying to get to the market first with their fish, as Waltair is a fishing village. They also carried water in lovely brass jugs on their heads. The women very gracefully did their chores in their clumsy but decorative saris. The men wore just a loin cloth or swaddling of dirty white cotton cloth. During our stay we even saw our clothes walk by. We found that when we sent our clothes out to be washed, the laundry people wore them a while before folding and returning them to us.

Our faithful servant Thomas cooked, took care of our room and watched over us, trying to prevent us from making errors. We learned that if we demanded our clothes be laundered and returned the same day instead of agreeing to a week, our clothes would not have been exercised for us by the wash women. Thomas proudly showed us the unattractive pieces of meat he was able to get at the native market which were so repulsive we thought we should starve, but when formally called and seated at meals, we ate it with relish.

We were entertained by an Indian who had been a student at Scripps, who lived in a thatched hut. We squatted on the ground and ate from banana-leaf plates with our fingers, waited on by his lovely Indian wife gracefully serving us. After our first mistake of not eating a meal prepared by Thomas before dining out, we learned to have some solid digestible food in our stomachs before the native food. Helping ourselves it was not difficult to make believe we were consuming a meal.

Our overnight train trip, supposedly deluxe, to Hyderabad was an experience. We had a private compartment and locked ourselves in. At each station swarms of beggars would try to open the door, as well as

travelers who peered in and saw empty places. At night they would pound on the door and try to force the lock. We had no food with us and none was served on the train, so at each station one of us would stand guard while the other procured food at a lunch stand. Since the food was unappetizing we settled for oranges, bananas and hot tea. There was no bedding, simply an upper and lower berth as soft as bare boards can be. I had some Thai silk yardage and made up elegant if not comfortable beds. We later learned that in India you carry your bedroom^l wherever you travel overnight. The heat was terrific, but we couldn't open the window because of coal soot and people who would try to climb in. The dust was terrible, as many of the stations were on dusty ground with no platform.

[back to F.P.S.]

We spent a couple of days at the Indian Institute of Science in Bangalore, staying at the home of the president and his wife. They were delightful people and made us feel very much at home, although we were a bit surprised when we found our beds consisted of the thinnest of pads and a most inadequate coverlet that did not begin to keep out the cool air of the winter night. We slept in our warmest clothes. We had a huge room and two adjoining baths for our exclusive use. Our hosts were vegetarians, but that did not bother us. When we went for a walk before breakfast next morning our host and hostess were also out and asked us to join them in their customary walk. We were gradually introduced to our host's children a few at a time.

The physics group in the area includes some of the world's great scientists, one a Nobel Prize winner. The country is lovely and we were charmed by the people.

One of the most interesting experiences of our Indian trip was attending the All-India Science Congress at Madras. The famous Nehru came to address the meeting and we sat right next to him on the platform while the preliminaries were being presented in long and boring addresses of welcome. Nehru would turn occasionally to the Indian professor on his other side and make some kind of whispered joke. Finally the chairman came to the main speech, and Nehru gave a magnificent talk, challenging the Indians to get to work with their hands as well as their minds, and to stop requiring menials to do all their physical labor for them. From what I had seen it was just what they needed. So much of the remnants of the caste system still prevailed, preventing Indian scientists from doing anything menial. I just hoped they were taking the advice seriously. Elizabeth and I were tremendously impressed with the entire talk. We later were invited, with the other foreign guests, to dinner with Nehru who, as the informal host made us all welcome. We enjoyed seeing him put his arms around the two pretty dancers who were going to entertain us after the meal, showing a very human side, that we had suspected from watching him on the platform.

There are some things that would trouble many Americans touring in India. For example, we had acquired personal art treasures, many of them gifts, and decided to send a box home from Madras. We labelled the box well and packed it carefully, sending it with a company supposed to be connected with American Express. When we got home there was no box. After months of waiting, and many letters of inquiry which were not answered, we asked a friend, a professor at Madras University, to

investigate. He asked some questions and there was then a long silence. Finally after a year and a half I saw an advertisement of the Indian Travel Bureau noting all kinds of wonderful things they would do for you. I wrote them what had happened. Shortly I got a reply from the express company in Madras stating, "You did not say where you were going after you left India and left no flight number." We supplied them that information along with dates and destinations. Six months later we got a notice from U. S. customs in San Diego that a box had arrived from New York; it went the wrong way around the world. It was the missing box, and when the customs people heard our story, they did not charge us anything. To our surprise we found everything in the box in perfect condition. Pure inertia in Madras!

After a delightful visit to New Delhi, and side trips to the Taj Mahal and the equally enjoyable Red Fort, we went from Bombay to the remarkable Agenta Caves with ancient murals on the walls. We left India and spent a few days in Pakistan.

There we were treated well by Navy officers and hydrographic engineers and I had a chance to learn something about the Indus Submarine Canyon which they had surveyed. Then I left to visit some geologists at Aramco, the huge American-operated petroleum company in Saudi Arabia while Elizabeth went on to Cairo. In Aramco alcohol was strictly forbidden, but I found that in the American colony everyone was making bathtub gin and serving it secretly.

I was taken out on the Persian Gulf and given a swim over a coral reef where, much to my surprise the water temperature was 60°F and wet suits were provided. I had always been told that coral reefs would not

live if the temperature got below 65°. This one did. We were there in mid-January, and were told that in summer the water is up around 90° in the same area. The petroleum company had good temperature records, which they showed me. An interesting experience was a trip to the desert and a visit to an oasis where we were entertained by nomads in a tent and given first coffee, then tea; or was it the other way around?

I joined Elizabeth in Cairo and we saw the pyramids, the Sphinx, and the wonderful Tuthankhamen gold and jeweled treasures that just recently were taken on a tour of America. After a visit to Turkey we headed for home with the loss of a day, just as in "Around the World in Eighty Days." Actually our trip was about the same length, but not as frantic as in Jules Verne's novel.

CHAPTER XII: EUROPEAN EXPERIENCES

In memory of Professor Maurice Lugeon of Lausanne, Switzerland who gave me the opportunity to join his summer field excursion in the Alps which unquestionably helped me to become proficient in French conversation which was a great boon to the rest of my career, and also taught me to be more tolerant.

I Learn to Speak French and Get a New Look at Life

As I have already mentioned, I did things badly if not interested in them, but my ability in these same things seemed to improve vastly when I developed the proper enthusiasm. In languages I was certainly a dunce. Latin almost drove me crazy in prep school. I never acquired a good grasp of that language even after some five years of hard work getting ready for college entrance exams. I received a 'D' in Spanish in my freshman year at Harvard. As for French, I had a French governess for a few years as a small boy but never did at all well in prep school at it, and actually flunked the first reading exam at Harvard, an easy test that everyone was supposed to take in a foreign language. Just a fluke got me through my German exam in connection with my Ph.D.. The examiners let us bring in a book to read and I chose a mineralogy and memorized all the words of a couple of mineral descriptions and so impressed the professor with words he did not know himself that he overlooked my glaring deficiencies. So that was my history in foreign languages when a few years later I got interested in really learning French.

Elizabeth and I went to Europe with my parents in 1925. We toured in their old Marmon car. Elizabeth was expecting our second child a few months hence and was not much on mountain climbing. The folks knew I was interested in that activity and so they offered me a couple of weeks by myself to climb the Matterhorn or whatever I wanted to do in the Alps.

While we were in Lausanne, Switzerland I went to see the grand old man of the Swiss Alps, Professor Maurice Lugeon, to talk with him about Alpine structure, in which I was very interested. He fascinated me, and at the end of our talk he invited me to join his annual international field trip with students and fellow geologists, to a part of the Alps called the Diablerets. This proved more interesting than climbing the Matterhorn, and I joined the group at their French pension in Gryon. I found myself surrounded by French-speaking people who, aside from one Canadian, knew very little English and were not interested in it. Nothing could have been better for my really learning the language. Having a smattering of French so that I could understand a good deal of what they were saying, I was forced to try my weak French on many occasions just to survive. The professor had quite a line of dirty stories and I had to have the Canadian translate those for me, but I soon found I was getting most of the rest of the talk as my ear grew accustomed to it. I soon began to jabber away with the rest of the group.

Having been brought up in a prohibition family I did not consume alcohol, but after seeing what fun the group had over their wines and liquors I decided maybe I was missing something in my life and began to join them on a very moderate scale. It sure made learning French easier and pleasanter. I was still somewhat of a puritan, so that the professor having along one or perhaps two mistresses did bother me some, but once again I decided I should become more broad-minded about the activities of others. So, I learned to speak French, enjoy a bit of alcohol, and became more tolerant of sex. In addition, I got a fine understanding of

the complicated structure of the Alps. That experience made quite a difference to the rest of my life.

Later while spending three months with Professor Bourcart of the Universite de Paris and talking in French almost continuously I became much better grounded in the language and greatly expanded my vocabulary, and for the first time began thinking in French. I even gave several lectures in French. I am still a poor linguist, and it is only because I got interested in learning French that I enjoy talking to French people when I encounter them, as I often do.

French Excursions in Marine Geology

In 1953 I began to have rather frequent contacts with French geologists and made many visits to France. Jacques Bourcart, professor at the Sorbonne, was the leader in French marine geology at that time and, hearing that I was coming to a conference in London, he invited me to take a side trip to Paris. After a wakeful night on an American military plane I landed at Orly Field. The loudspeaker called my name and I was ushered out and given the red carpet treatment by Bourcart and whisked through customs and immigration. Taken to my hotel, I was given a few minutes to freshen up and then escorted to the Sorbonne where a gathering in Bourcart's office treated me to morning champagne. After a tour around the offices where I practiced my still somewhat weak French on various professors and graduate students I was taken to a bistro and had a hearty lunch with three kinds of wine. The afternoon activities grow a little vague in my memory, but I am quite sure that champagne was served several times. Later we had wine at Bourcart's

apartment and I met Madame Bourcart. Dinner must have included several more wines but I lost track during the evening.

After dinner we all had an espresso in a little cafe before going to a very French musical review, nothing like the Follies, which is very American. The espresso woke me up alright; in fact, it woke me so much that I did not sleep a wink until about 8 o'clock the next morning, sleeping only until 9:30 when another French professor called to take me in charge for Sunday activities, to see some field geology in the Paris outskirts. Fortunately I had a reservation to fly to London late that afternoon and was able to recuperate at Sir Edward Bullard's castle-like residence in Teddington before the next conference.

My next French visit was in the spring of 1955. I still don't see how I got away from the API project so long, as I spent a couple of months in France on that occasion. Elizabeth was with me, and Robert ^{L.} Fisher, then a graduate student, now well-known to marine geologists.

Bourcart had arranged a symposium with the Dutch marine geologist, Philip Kuenen, several French geologists including Mme. Gabler of Petrole Francaises, Bob Dietz and myself from the U. S. I had been brushing up considerably on my French and gave my papers in that language. Kuenen followed suit with a rather strong Dutch accent as I recall, so that the meeting was almost entirely in French.

While waiting for a few days to go on a student field trip along the coasts of Normandy and Brittany we were entertained by various French geologists, always in small bistros. I remember one time a group of eight Frenchmen invited us to dinner, but instead of talking to us

during the meal they spent the whole time gossiping about their mutual friends. They completely left us out of the conversation so we just sat there and no one seemed to notice anything wrong in the picture.

The field trip was interesting, although to our California-attuned temperature buds the early April chill along the seashore of northern France was a bit grueling. I remember one morning coming down for breakfast in the small inn where we stayed to find all the doors and windows open to the fresh air, and the temperature outside was about 40°F. Luckily we had borrowed some warm coats from our Boston relatives.

One thing that did impress me was that the French kept referring scornfully to the supposed 6-meter high stand of postglacial sea level that was so popular in European geological circles at that time, and was also advocated by my old professor, Reginald Daly. I had never seen anything that supported the idea, and the French coast seemed to have terraces at all sorts of levels and ages, with no uniformity.

Returning to Paris we prepared for the usual Bourcart summer visit to Villefranche where the Paris marine station is located. Traveling in their small French car, Madame Bourcart drove all the way, with Elizabeth in the front seat and Bourcart and myself in the rear. He held the road maps and woe be to him if he gave her a mistaken direction -- she complained bitterly if he did not give her the route correctly. I particularly remember, also, that we stopped every hour or so at a tavern and the Bourcarts would have a little snort of alcoholic beverage. They seemed to run down rather quickly and needed a new boost periodically. At least it did not seem to impair Madame's driving, even after three kinds of wine with the interminable French dejeuner (often two hours) in

the middle of the day. I suppose you get used to the alcohol, but I did note that both of them died fairly young, and other^s of our French friends who avoid alcohol are still alive. Of course, the continuous cigarette in Bourcart's mouth was no help.

While at beautiful Villefranche, located between Monaco and Nice, Bob Fisher and I had the opportunity to go out on the French Navy ship, Elie Monier, which was devoted to oceanographic research, and particularly to scuba diving operations. The truly delightful captain was a fiend for diving. He was always the first one in the water after we anchored, and the last on board before we left. He usually had to go into their decompression chamber as he didn't take enough time to decompress on the way up from rather considerable depths. It did not seem to hurt him.

The trip gave us a fine opportunity to make soundings and collect samples in the submarine canyons. These valleys are quite amazing the way they extend in along the coast, so close you could make out the scant bikini bathing suits at the famous French resorts that are just inside these canyon heads.

Lunch on shipboard was a ceremony. Everything was shut down; aperitifs and several courses, all with the correct wine, and a liqueur to top it off. One did not usually have too much enthusiasm for work in the early afternoon.

We also surveyed the canyons around western Corsica. It was fascinating to see how they related so closely to the river canyons on the adjacent land, quite different from the submarine canyons off California, where I had done most of my earlier work. Our effort came

to an abrupt end when we encountered a mistral, one of the sudden storms that can hit the Mediterranean and make life miserable aboard small ships. We sought the lee of Corsica Island, and returned to Villefranche after the storm had blown itself out.

[by Elizabeth]

While Fran was out on the Elie Monier with Professor Bourcart, I was left in charming Villefranche in a small, intimate hotel with a balcony overlooking the bay. The hotel was a family affair and there were uncles, aunts, nieces and nephews pressed into service by the management. They were a jolly lot, speaking only French, and with my stumbling French and sign language, we enjoyed each other. Mme. Bourcart, who was the chauffeur when Professor Bourcart was around, never left the porch, and evidently was not able to drive without her spouse to tell her every turn to take. I did her errands, even buying cigarettes and going to the poste for her.

There was fine bus service along the Mediterranean as far east as the Italian border, and west to Nice where the bus terminal was located. I took every one of the radiating bus routes, leaving early in the morning. At the various destinations I would prowl around the Alpine villages all day, having lunch, and returning on the last bus. What fun! And what beautiful little hill towns, such as Grasse, where the perfume is made, and Picasso's home where they make lovely ceramics. Villefranche, too, was quaint and in my many walks I became friends with shopkeepers and mothers sitting in the park, watching their children playing and chatting with other mothers.

[back to F.P.S.]

A short time later Bob, Elizabeth and I all joined one of Bourcart's students, Francois Ottman, who was working on the land geology of the Corsican coast for his doctoral thesis. He had a "Deux Cheveaus," as they called the small Citroens, and toured us all around the island. We were particularly delighted with Porto, and took a trip in a small boat to one of the tributary bays where we climbed the hill to look down on a series of submarine canyons outlined by the dark blue of the deep, clear water, contrasted with the green of the shallower water. This was my first actual view of a submarine canyon. Our geologist guide knew a couple who were camping in a deserted old Genoese watch tower, formerly a lookout for pirates, at the top of a small hill. Our friend Francois let out a yell and a bikini-clad girl appeared at the parapet on the top of the tower and waved. She came running down, embraced our friend warmly, and invited us up to enjoy the beautiful view from the top of the tower. Her husband soon returned with a large fish he had caught in the bay. We enjoyed a delightful meal - no three-course affair this time.

He was a French Navy officer on leave and this was their Corsican hideout. They were surely living the simple life, with almost no furniture, but what a glorious view, to say nothing of his beautiful wife. It is on occasions like this that one's French shows vast improvement.

These impressions which I obtained of French scientists were undoubtedly based on too small a sampling to form any good basis for an opinion of the French character in general. However, one cannot fail to note some support of these impressions by following newspaper accounts

of the relations of the French statesmen with those of other countries of the world. As individuals, one can find all kinds, from the most kind-hearted and generous, especially in the country towns, to the most selfish and thoughtless. We have encountered both types in our travels, and have alternated between being snubbed and warmly embraced. As I go over my collections of reprints there is no question but that I have received more from the French than from scientists of any other foreign country.

Well, after our French visit I was soon speeding back to API Project 51 and the grind, to satisfy my committee.

Visits to Great Britain

There has certainly been a great difference between our visits with French geologists and our experiences with the British. It is not only that the language is no problem, or let's say less of a problem, unless dealing with a strong Scottish burr or other dialect, but they make one feel so much more at home.

My first visit to a home in England came directly after the rather strenuous 30 hours in Paris. My friend Teddy (Sir Edward) Bullard was at that time director of the huge National Physical Laboratory at Teddington, and a large residence came with the job. He and his first wife Margaret, both old friends from their La Jolla days, invited me to visit them while I was attending a conference on submarine geology in London. I say, it was a fine old historic home, but servants were not included, so it was with real informality that we lived; breakfast in the kitchen.

The grounds were cared for by the government and were beautifully kept up, like those of an earl. The children, three girls, were all individualists, and Margaret combined being a writer and having many other skills such as making costume jewelry commercially. Visitors came and went. My friend Harry Hess, a well-known Princeton professor, joined the household on the second night of my visit. I had once criticized him rather severely for an article he had written about submarine canyons, as I had also criticized Teddy Bullard, but these were in the past. I probably was at least as wrong in my opinions as they were in these early attempts to explain canyons of the sea floor.

Anyway, the conference at the Royal Society was very enlightening and everyone presented conflicting, thought-provoking opinions, and authors were quite frank. The meetings were followed by dinner at the Royal Society where, much to my surprise we all had snuff passed to us. No drinks were had until the then brand-new Queen's health had been proposed. I sat next to Aldous Huxley and immensely enjoyed talking with him.

This short visit to England left me with a warm feeling toward the English, and it has never changed. Teddy and his second wife, Ursula, later became close neighbors in La Jolla and we became warm friends. Sadly, this great geophysicist died in 1980.

When I was given the Wollaston medal of the Geological Society of London in 1966 our friend Perce Allen, a professor at Reading University invited us to visit him and his wife before the presentation, and asked me to give a talk before the Geology Department where he was the outstanding professor.

After the long flight from California, nonstop, we arrived very tired. Perce knew how we felt, though, and took us to his home where he put us to bed with a warming pan -- despite it being May, it was frigid in the bedroom. He said to sleep as long as we wanted, and we awoke much refreshed. We became like members of the family and were made more than welcome. They were delighted when I helped him cut the lawn. After showing me the Reading Geology Department the Allens took us for a tour of the area which included Stonehenge. In the late evening they took us out into the woods to hear the nightingale; we had many such pleasant experiences. On the day I addressed the students and faculty at Reading the students took me out for a bachelor dinner that was delightful and quite informal.

I must mention one of the differences in our idioms of conversation. The night before we were to leave for the continent, Perce said to Elizabeth, "I hope you won't mind if I knock you up at six o'clock tomorrow morning."

The ceremony of my receiving the medal at the Geological Society had one rather amusing incident. Before introducing me to the Society they had a meeting of the members and, as I was not at that time a member, I was taken to a small cloakroom to wait while the meeting progressed. Aside from that, the rest was very friendly, including the banquet that followed. Here we were marched in; the President of the society and some higher officials, already seated, rose until we were seated with pomp and fanfare by special lackeys who were stationed behind our chairs. The Queen was, of course, toasted. Otherwise everything

was very informal. When I was introduced I did put my foot in it by forgetting to wait for my name to be announced with the usual fanfare before getting up and starting to speak. No one showed any notice, and I gave an informal talk which seemed to be appreciated and was given considerable applause.

The ceremony of the proceedings reminds me of attending a conference in Bristol. It was sponsored by the Colston Society and was an informal gathering; one evening our friend Teddy Bullard was the speaker for the meeting. We were all seated in the lecture hall when the order came to rise, as if the judge was about to convene court. In swept Teddy in a pompous parade with some buxom dowagers and the mayor of the city, replete with massive gold chain and all his medals. We were then allowed to be seated. After a fine talk we waited until the "royalty" were ushered out and then proceeded to a ballroom where refreshments were served. Here was the catch: One table was beautifully set, for the use of the revered and honored guests; the rest of us had to go to a lesser table and buy our refreshments. Elizabeth and our friend Hazel Rakestraw waltzed up to the wrong table and were told to desist.

That was better treatment than received at a meeting in Antwerp, when all delegates to an international sedimentology congress were invited by formal invitation of the mayor to the city hall. After a long wait the mayor entered and addressed us in Flemish. Then he said in French, "Since there may be a few here who do not understand Flemish, I will repeat in French." The majority of the audience spoke only English. A rapid tour followed, through the fascinating city hall with its fine paintings and beautiful architecture. At this point our tongues were

hanging out for the fine refreshments we were anticipating. However, we were told, "That will be all. Goodnight!" Everyone had come expecting sumptuous refreshments. We had eaten nothing before coming to the reception and were now starving.

Aside from the one slightly stuffy affair in Bristol, our English hosts were always most hospitable and if anything, we suffered from too much good food. They showed a real joy in making all their guests happy. I often wonder how the English got the reputation of being so reserved and unfriendly. It must date back to the Victorian era. Whether encountered at meetings, in travel, or in their homes, the British seem as a race to be delightful and humorous. Possibly many Americans may not find this so because they are in too much of a hurry to strike up an acquaintance. A little delay does wonders, and some group ceremony is still maintained.

Going on field trips with English geologists is particularly pleasant; they point out things of interest and seem anxious to get your opinion of how things were formed, rather than telling you their ideas. They often include points of historical interest. This reminds me of the title in a British scientific journal: "How to Make a Broad." No joke intended; a "broad" is a special type of marshland found around portions of the North Sea.

Experiences with Soviet Geologists

I suppose it is difficult to get true impressions of Soviet scientists from encounters with them at meetings or on cruises and geological excursions. However, I find from talking to U. S. colleagues,

and to my son Tom, a medical research doctor and professor who also has gone to Russia for many conferences, their impressions of the Soviets are pretty much the same. First, that most Russians are just delighted to talk with you and to express in every way their friendly feelings towards Americans. They don't try to convert you to Communism.

We went to the apartment of a friend in Moscow which looked awful on the outside, like a tenement, but on entering it was charming, if a bit overcrowded with fine antiques; they even had two pianos. We admired something and they took it off the wall or off the table and handed it to us. How could we refuse? Drinks are quite numerous and everyone got in a jolly mood. One guest whispered behind his hand to Elizabeth about what happened to his father, a doctor, during the Stalin regime - that he suddenly disappeared, never to be heard from again. There is no discourtesy on the street because you are American. The people know, and smile pleasantly and try their English with real relish. English is the second language.

In 1966 we attended the International Oceanographic Congress in Russia. The experience going from Leningrad to Moscow is perhaps not too unusual for Russian travel. Before our flight, at the hotel, we were called at 3 a.m. in the morning - it should have been 5. We dressed at 5:00 and went down, but could not get a bite to eat in this once-elegant hotel, still the largest in Leningrad. It was terribly run down in most ways. "Well, that's okay, we'll get breakfast on the plane." We left the airport for Moscow at 7:00, but to our dismay they served nothing but a glass of water en route. There were not even seat belts on the plane. "Well, our friend Zhivago is meeting us at the airport. We will

then soon have breakfast." Our friend, a marine geologist, met us and whisked us off to the large Ukraine Hotel. There we went to the end of a long line of tourists and inched our way slowly to where papers and reservations were being examined. After an hour and a change to another line we got to the right desk and showed them our confirmation of paid-for reservations. A half-hour of rummaging, and they said, "We cannot find any such reservations." We showed them all sorts of proof that we were attending the international congress, and confirmation of everything. They finally said, "Oh, you are in the wrong line." We had another hour of waiting and another dispute over our reservations. Our friend Zhivago was still with us, trying to help. At last they said, "Here, we can put you in room 708." Squeezed, and I do mean squeezed, into an elevator so that we could hardly breathe, we reached the seventh floor. We hurried down the hall toward our room, me slightly in the lead, and I saw to my horror that the door was open and they were papering the walls! At that our Russian friend exploded and swore violently (we supposed) in Russian. He went to a hall telephone and shouted to the desk in loud and authoritative tones. Within two minutes we got a real room and, descending to the dining room, had a slight delay in getting the bored waiters to serve us our breakfast.

My secretary, Margaret Miller, had found that I could get a sum of rubles in Moscow because one of my books had been translated into Russian (though no permission was asked). A pleasant young lady took me down Peace Avenue to the Peace Publishing Company where, after some maneuvering, looking through large record books, they found Submarine Geology, my book,

listed. "Oh, that is too bad," they informed me. "That came out two years ago, so the sum is no longer available." I replied something like, "Well, I did not expect any royalty anyway."

"Oh, wait a minute! Your book The Earth Beneath the Sea was translated recently." "But how can there be any royalties?" I asked. "There are not royalties; we pay by the number of pages and illustrations," they told me. After some delay I got 470 rubles. What to do with them? I had paid for everything through Intourist before arriving in Russian, and the stores had nothing but fur and jewels so far as we could see. Then a solution came to us. We gave the rubles to associates who ran short of money while there, and would get their checks in dollars on returning home. It worked out fine and when we left we had only about 10 rubles left, which they actually gave us a dollar each for, which was far more than they were worth on the open market.

I must tell of our first experience with Soviet geologists in Switzerland at an International Sedimentologist meeting. Back in 1958 the Soviets always had one or more commissar^s keeping track of their scientists when they visited other countries. However, the Soviets had some bibulous parties at which both the commissars and scientists got pretty talkative and let out some things that I am sure were supposed to be taboo. After one such party we went on a field trip the following morning and some of the Russians looked ~~the~~ the worse for the indulgence that preceded at the Russian Embassy.

We climbed a slope through the vineyards with some lovely views of Lake Geneva. We were admiring the view from the top when one of the Russian commissars decided to make a count. Sure enough, one Russian

geologist was missing. There was great excitement and a jeep appeared and off went the commissar to round up the missing member while the rest of us began speculation on his having escaped the iron curtain. "Oh," one Russian said, "He does not have any money, any passport, and could not get away." He was right; he didn't escape, he just got sleepy and saw a bench and went to sleep behind a hayrick.

I once had an argument with Scott Carpenter, the astronaut and scuba diver, about the Soviets and oceanography. We were both getting honorary degrees at Beloit College and the press were, of course, hanging on his every word. Someone asked us whether we thought that the Russians were getting ahead of us in oceanography, as they had at that time (1968) in space travel. I said rather rashly that I thought the Russians were being spectacular with their large ships and some amazing instruments, but that we, with our freedom of research and dedicated scientists and numerous small ships were going to lead the race.

"Don't fool yourself about that," Carpenter said. "We got fooled enough in thinking that we had space travel all in our hands, and look what happened to us then." Of course, the level of 'space' research later changed sides in many respects, and American marine scientists have taken a solid lead in oceanography, despite some of our stupidities. Let us hope that we can hold our own in military matters, where we seem to have slipped badly as this is being written. Our funding of research is now on the decline, and the future looks none too bright. We still have the great advantage of having free men who want to see us win the struggle, rather than more or less enslaved scientists, as on the other side.

CHAPTER XIII: CONTINUED EXPLORATION OF SUBMARINE CANYONS

Dedicated to Jacques Cousteau, for the opportunity to make deep water dives in his Diving Saucer, and his remarkable pilots, providing me with my first opportunities to view the submarine canyons which I had been studying by other means for so many years.

General Studies off California and the Tip of Baja California

For a number of years after finishing my tour de force of API and the sediments of the northwest Gulf of Mexico, I devoted most of my time to the study of the submarine canyons of the San Diego area as well as those of the tip end of Baja California where they proliferate. Both are areas where land canyons are not particularly well-developed near the coast, partly because of the low rainfall. Since rivers can cut only above sea level, one would think that canyons would be much more striking on the land than on the sea floor, but actually there are a number of regions in the world including the northeast coast of the United States, the west coast of France, and the entire coast of Ceylon (now Sri Lanka) where the canyons of the marine slopes are much more spectacular than those of the adjacent lands. This is shown rather surprisingly well when one compares profiles across the land valleys and across the sea canyons in the same area. I learned this fact back in the late twenties when I was accompanying the U. S. Coast and Geodetic Survey ships off Georges Bank. In 1934 my soundings using wire and a hand-operated winch revealed that the California marine canyons had sections where the walls were essentially vertical, which was impossible to tell from echo soundings since the echo comes from the nearest good reflecting point in a relatively small arc beneath the ship from which the soundings are being made.

The investigations during the period of funding from the Geological Society of America helped establish the vast size of the submarine canyons off California; the Monterey Submarine Canyon, for example, was shown to be comparable to the Grand Canyon of the Colorado River. It remained to establish more completely the character of the sediment on the canyon floors and of the rock on the canyon walls. This I set out to do, with considerable help from colleagues and students, as well as some assistants who had been assigned to the work as the result of grants from the Office of Naval Research and later the National Science Foundation. Foreign visitors -- including Arnold Bouma from Holland (now with the U. S. Geological Survey), Ulrich von Rad from Germany and David Piper from England -- were a great help in this program. Thus Arnold Bouma, working with us at Scripps Institution, perfected his version of the box corer first developed by Hans Reineck. The box corer allowed us to obtain almost undisturbed cores from the canyon floors where we previously had got very little but bent core barrels. These cores were particularly helpful in studying the effect of turbidity currents in the canyons.

Monterey Submarine Canyon, the largest on the California coast, has always intrigued me. What happened to it in a seaward direction? In 1956 we did not have available any good method for electronic positioning out beyond where we could get visual fixes or radar, a distance of about 30 miles. Some of the southern California marine geologists, including our students, had thought from their dead reckoning positions that the outer portion of Monterey Canyon had a three-way distributary,

just as the Mississippi divides into three branches, or passes, at the Birdfoot Delta. To check this interpretation I took along a buoy with radar reflectors attached, took it out into what appeared to be the center of these three-way divides, and dropped it with an attached anchor. When it was moored, we started a systematic survey using distances and directions from the buoy for controls. It worked, and somewhat to our surprise showed not three channels but one large meander. This solution was quite a novelty at the time, as geologists had thought of meanders as being exclusively a feature related to rivers.

In 1959 we began the first of a series of cruises to Cape San Lucas and from there up into the Gulf of California. I had been fascinated with the submarine canyons that we discovered in 1940 at the lower end of the peninsula, at the entrance to the Gulf, but we had not had the time and equipment then for really examining them.

The canyons at Cape San Lucas interested me particularly because the rocks at the Cape were mostly granite, in contrast to the much softer sedimentary rocks we encountered in most of our study of California canyons. When we had the opportunity to examine the canyons on the sea floor off San Lucas we found that they were also cut in these granitic types of rock.

In our first expedition we had with us some scuba divers whom we put ashore on a small beach (tombolo it is called by geologists) that connects some of the spectacular outer rock pillars at the Cap with the mainland. Camping on this beach, the party was awakened one night by large waves which had begun to pour over the tombolo from the open ocean, forcing the campers to move hurriedly to higher ground among the

rocks. The next day the large ocean waves subsided and the boys, under the leadership of our fine scuba diver Conrad Limbaugh, dove into a small tributary submarine canyon that starts almost directly bayward from the tombolo. To their surprise they encountered streams of sand moving slowly towards the canyon head and falling into a gorge like a waterfall. Another first had been rung up: rivers of sand on the sea floor. We will always remember Connie in connection with this discovery. Unfortunately he died a few years later while exploring a French underwater cave, where he ran out of air.

Our explorations of the Cape San Lucas submarine canyons continued for a good many years.⁵ We found that the sediments on the canyon floors, instead of becoming finer-grained as one progressed into greater depth, either became coarser or alternated between very coarse sand and gravel, and included some zones where the bottom was muddy for short distances. It was quite a surprise to find sand as coarse as that of the San Lucas beaches even at 5000-ft depths. The canyon walls were steep, sometimes even vertical, and were usually hard rock-like granite, indicating powerful erosive forces had operated on them, or were still operating. Narrow gorges like that of Scripps Canyon were discovered where one could actually touch both sides at the same time.

One attraction of exploring the Cape San Lucas canyons was the opportunity to observe the marine life of the area. Sea lions inhabited the outer pinnacle rocks at the tip of the cape and would often swim by

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F. P. Shepard, 1964. Sea-floor valleys of Gulf of California, in: Marine Geology of the Gulf of California - A Symposium, Mem. No. 3, Amer. Assoc. Petrol. Geol., Tulsa, Oklahoma, pp. 157-192.

the scuba divers. Grey whales frequented the Cape and would come in almost to the shore and scratch off their barnacles on the rocks right next to us as we were walking on the beach. The whales also showed friendly interest in us as we cruised around in small boats; they came up to look us over, but always carefully avoided hitting our craft. The fish population of the area is well-known to sportsfishermen. We had no interest in catching the huge marlin for a photo that shows the fish hanging next to the "sportsman" on the scale near the pier, dwarfing the fisherman. We enjoyed going through a school of jumping manta rays that often could be seen splashing all around us. The sharks seen during dives were somewhat worrisome, but we had no attacks during swims. We used to go swimming occasionally from a rock, which someone named after me. It was unique, having almost vertical walls that descended sheer to about 200 feet into the canyon. Beautiful coral growths lined this rock as far down as one could see, and lovely tropical fish swam in schools around these walls. That was some 20 years ago and our occasional visits to the Cape in more recent years has shown the effects of pollution in some places. As the resort at San Lucas has grown, with many hotels and more and more sewage enters the water, and more waste comes from the local cannery at the canyon head, the lovely clear water seems to be a thing of the past in this bay. It is the same at many other resorts on the west coast of Mexico. Alas, the new highway from San Diego has done much to spoil this interesting area. It's true, you did take your life in your hands when you flew to Cape San Lucas in the old days, with Rodriguez in his small planes, but you still do when using the narrow highway to the Cape, having to get off the

road when the reckless Mexican truck drivers whiz past, to say nothing of the wild burros that cross the road at night, sometimes forcing you off the pavement.

Cooperative Studies of Tokyo and Sagami Bay Canyons with the Japanese

In 1962 I had a month's use of the Scripps ship, Spencer F. Baird for a cooperative study of the submarine canyons in the area around Tokyo Bay entrance and Sagami Bay where the great 1923 earthquake had its epicenter. My friend, Professor Hiroshi Niino of the Japanese School of Fishery agreed to obtain the cooperation of a Japanese Fishery ship, Umutaki Maru, to work with us. We thought everything had been satisfactorily arranged for the diplomatic permission by Niino, but when we arrived in July by plane to join the ship, he explained that a few formalities had to be completed. We started early one morning, and Niino and I went from one government office to another all day, always greeted with politeness and given a cup of tea and pleasant words, but always informed that they were afraid we would have to go to still another office. Finally I said we had better just work outside the 12-mile limit (the good old days before the 200-mile limit was in vogue). Niino said he would make one more attempt, and sure enough, the next morning he showed up at our ship with a paper in Japanese which, he said, gave us permission to do near-shore studies. Our captain, who happened to be the most difficult of all the Scripps captains, was very unhappy about the paper, claiming he did not want to get his "ass in any Japanese jail," but we finally persuaded him to take a chance and trust Niino, after we had the captain of the Japanese ship confirm the document's translation.

The plan worked out very well. We took Japanese students in shifts, and sent our American students over to the Umutaki Maru in an exchange that was most cordial and pleasant. The Japanese were surprised to find a lady aboard, and they all took Elizabeth's picture.

There were two things that troubled us on this expedition: One, the small Japanese fishing boats seemed to have no idea of right of way, and we constantly had to stop our sounding lines to let them pass. The other problem was the heat. It was July and the temperature never seemed to go below 90°; no air conditioning at that time on the Baird.

However, we did succeed in tracing seaward the fault valley in Sagami Bay where, according to the Japanese, depths had changed radically in 1923 during the earthquake.⁶ We found this fault valley to be in many ways very much like a submarine canyon and, in fact, it had a series of typical canyons entering it from the east side, but none from the west, where fairly recent volcanic action had occurred. We obtained photographs on one canyon floor showing vivid ripple marks which at the time was quite a novelty, although this now seems to have proven to be a feature commonly true of submarine canyons the world over.

When we were ready to leave Japan we were asked by a Japanese cable company if they could see our survey, and we went to great pains to give them a preliminary draft. They were very appreciative: They had a geisha party for us and gave us a rather nice little radio. They asked us what the charge was for the draft, and I said there was none. When Elizabeth

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Niino, H, T. K. Chamberlain and F. P. Shepard, 1964. Submarine canyons and Sagami Trough, east-central Honshu, Japan. Geol. Soc. Amer. Bull., 75, 1117-1130.

and I later arrived in Singapore we found two Japanese gentlemen from this cable company had waited up all night to meet our plane, which was late. They spent the day taking us around the area and treated us to a fine meal before putting us on an evening plane for Australia. It struck me as a bit strange at that time to be escorted around Singapore by Japanese, who had enslaved the place not so many years before.

Submarine Canyons of the Hawaiian Islands

In the spring of 1963, about a year after the work with the Japanese, I had the opportunity to use, once again, the Spencer F. Baird, this time to examine submarine canyons off the Hawaiian Islands. This was particularly interesting to me because almost all of my previous work had been done on canyons off continental areas. Hawaii on the other hand is thousands of miles from any continent and is known definitely to have been built up by submarine volcanoes, some of which are still active. The island of Hawaii, for example, with its ^{all} ~~Mauna~~ Loa and Kilauea volcanoes, and one that probably erupted in historical times, Haleakala located on Maui.

Examination of the Coast and Geodetic Survey charts showed a clear relation of submarine canyons to the times when volcanic activity had been active. Thus the northwestern islands of Kauai, Oahu and Molokai seemed to have a monopoly on submarine canyons, and these were known to have been built up by the most ancient of the Hawaiian volcanoes. The canyons off the spectacular cliffed coasts of Kauai and eastern Molokai appear to be the best developed, particularly since these canyons come in closer to the shore than those off Oahu, which have apparently been partially filled by coral reefs.

We started off on the Baird from Honolulu one stormy morning following a late night for most of us who had been enjoying the hospitality of friends. With a few exceptions, we did not have our sea legs well developed and felt most uncomfortable after rounding the protecting Makapuu Point and feeling the full effect of the strong trade wind and rough seas. In fact, one of the professors from the University of Hawaii was so sick it took him two days to recover; the rest of us were ready for work when we reached the north coast of Molokai. We began a systematic survey of the canyons that extend along the beautiful Pali coast, past the leper colony peninsula. We were particularly impressed by the fact that every time we passed the first large land canyon on the western side of the Pali, and could look straight up the canyon from the ship, our fathometer was always crossing the deepest part of a submarine canyon located directly off the land canyon. There seemed to be no doubt but that they were connected in some way. Less clear connections existed between the land canyons and other submarine canyons, but it was not hard to tell that there was some relationship. Only off the leper colony peninsula, where a relatively new volcano had built out beyond the Pali, was this relationship missing. Apparently the canyons off this peninsula had been partly filled by volcanic flows, as they did not extend in close to the shore.

After completing our work off Molokai we sailed for Kauai and tackled the Napali coast on the northwest side of the island. Again there are great cliffs coming down to the waterfront, and the submarine slope is cut by canyons. Here, once again, we found that the canyons showed considerable relation between land and sea, and all canyons are definitely located off the great

sea cliffs of this deserted area which is called the Napali coast. The history of the Hawaiian Islands seems to offer a possible explanation for the submarine canyons. It is now quite well established that these volcanic masses have undergone considerable submergence. Plateaus off the islands show remnants of much shallower water conditions than now exist. Also, borings in the coral formation on the island of Oahu show that this island has sunk at least 200 feet. Furthermore, it is generally found that old volcanic islands have undergone considerable submergence. Thus it seems possible that what is now submarine canyons may once have been above sea level in times past. According to some descriptions of the Molokai canyons, in an unpublished manuscript by Neil Marshall and Charles Hollister, the appearance of the walls and floors observed from the U. S. Navy deep diving vehicle were decidedly those of subaerially eroded surfaces.

However, one can not conclude from these studies of Hawaiian Island canyons that submarine canyons in general are the product of subaerial erosion. There is much independent evidence to suggest that turbidity currents are a major factor in producing and modifying most of them.

Deep Canyon Dives at La Jolla

Shortly after World War II I became interested in scuba diving. Several of my students and assistants had become qualified, and I was anxious to get down into the heads of submarine canyons so I could see for myself what others were beginning to describe and photograph. Unfortunately, my ears caused me a lot of trouble and I finally gave up diving after some unpleasant experiences. For a decade or more I had to depend on the accounts of colleagues and students who succeeded in

diving into the canyons to depths of as much as 250 feet, bringing back fascinating accounts of what they had encountered in the canyon heads. Then at long last, I got my chance.

Jacques Cousteau asked us at Scripps if we would like to charter the Soucoupe, his diving saucer, to have a look at the interesting features which Robert F. Dill had described to him from the La Jolla area. Should I! It was a golden opportunity. We obtained funds from the National Science Foundation and Cousteau supplied his well-trained pilots who added greatly to our success. Again I was glad to be able to speak French.

Thus began a new era in my life, and certainly one of the most soul-satisfying. On February 5, 1964 I climbed in the Soucoupe which was on the deck of the small tug, Surftide. In the interior of the saucer you lie on your stomach so as to look out one of the forward-facing portholes. The hatch was fastened above us, and the saucer was swung over the side with a crane and lowered gently into the water. A skiff towed us to the location of our planned dive, we were released from the line by a scuba diver, and we then took on water enabling us to submerge and descend gently to the bottom. It was only 100 feet deep, and scuba divers were swimming about, pointing out features exposed on the canyon walls. The water was rather murky and somewhat disappointing at first.

Turning on our small jets for propulsion, we started down the axis of Scripps Canyon and left the divers at a depth of 150 feet. The water became much clearer as we descended and as the light from above faded, we turned on our powerful headlamps and could see the rocky cliffs first on one side, then on the other. Many fish swam past the porthole. In

the powerful lights beamed ahead I saw several large rays that looked like huge bat^s, not at all disturbed by our presence. A narrow tributary canyon with vertical walls appeared on our left side and we began our photography; we have both movies and stills, punctuated by flashlights. Our conversation was recorded continually on tape. Pretty soon the descent steepened so much that we were practically standing on our heads going over what would be a waterfall if it were a land valley with a stream in it. This brought us soon into a larger valley to our right, and we continued down this, passing over many more potential 'waterfalls.' These abrupt descents are partly due to large boulders that have fallen off the sides and allow sediment to build up the channel on the inside. Everywhere the walls to either side were essentially vertical, even overhanging in some places. Beautiful anemones and gorgonian fans with waving arms were attached to the walls; they are far more colorful by searchlight than in the pictures I had seen taken by natural light. Shrimps lined the walls along with tube worms, which have flower-like antennae protruding from their tubes which they retract when approached.

After a little over two hours (which seemed like minutes), just beyond a narrowing of the gorge, we started our ascent, following a vertical cliff about 100 feet up. We had to frequently push off the cliff because of overhangs. We came to a terrace edge with sand on it, alternating with rock ledges, and finally to a broad sandy slope, from which we rose vertically to the surface. We were picked up almost immediately as the surface crew had been tracking us by a pinger that sends off sound waves from the diving Saucer, and is monitored on the surface skiff. When we got aboard the support boat and they opened the

hatch, I came out to a cheering group, everyone taking photos of the man who had studied submarine canyons for 30 years, but had previously never seen one. They all shook my hand and I hurried over to have a hasty lunch before a brief conference and the second dive.

This time we went down in Scripps Canyon where the water was about 800 feet deep. It seemed to take forever to get to the bottom, and the walls which had sloped rather gently became steeper and steeper. Finally, as we descended a vertical wall within a couple of feet of the rock on our view side, we bumped the rear of the saucer on the protruding rock wall on the other side of the gorge. This was a very narrow place and required some care, as the submarine is not very maneuverable. The excellent operator, Andre Falco, a Frenchman who spoke little English, maneuvered along the gorge carefully, looking for a way to the bottom. We found that the walls got so close together that our 10-foot wide saucer could not descend any further. We could see that the bottom, a few feet below, was wider, giving the canyon an hourglass shape. The driver moved us along the axis until we at least found a place where the walls were farther apart and we could touch the bottom. There were a few rock ledges crossing the floor, and the walls continued to be vertical.

Our main batteries were getting a little low so we decided to go back up, following the rock face, observing the fish and wonderful sea anemones, along with fan corals. Back again to the surface, and that was all for that day. It was one of the best days of my life. I felt I learned more about canyons that day than in 30 years of remote control study from the surface.

Two days later I dove again, this time starting in La Jolla Canyon, which is wider than Scripps Canyon, and where the walls are not quite as steep, although they are vertical in a few places. We coasted slowly down the valley floor, encountering the juncture with Scripps Canyon at a depth of about 900 feet and went a short way up that valley to see its character and find the nature of the contact between the two valleys. Many large, slow-moving crabs were on the floor of these outer valleys, along with lovely red fish and a few flatfish that live partly embedded in the sandy floor. Again the sea animals seemed to pay almost no attention to us.

After we had explored the mouth of Scripps Canyon we went on down La Jolla Canyon, passing huge boulders that partly covered the canyon floor. These boulders had virtual rock gardens of large white sea anemones and little pink corals growing on them. We had to climb over them to continue on our path. When we finally reached about 1000 feet, the lowest we were supposed to go in the saucer, we called it off and began a slow ascent of the lovely walls with their plant and animal life. We saw an octopus crawling away from us at one point. The walls reminded me of Zion Canyon in Utah.

We finally got to the terraces and sand slope, and returned from a 3-hour dive. Again I was greeted with great enthusiasm at the surface. I am afraid I have not conveyed the true beauty of the scenes that I had the pleasure of seeing for the first time. They are so completely out of this world, and so breath-taking, that it is hard to concentrate on their scientific significance.

So I had a fine chance to use my French. I feel as though the operator is now a good friend. Elizabeth and I invited the Cousteaus and their pilots to our home for an informal lunch in the patio. They kept arriving for hours after the time we had mentioned and food began to get scarce, but Mme. Cousteau joined Elizabeth in the kitchen and more sandwiches were made; these were accompanied by drinks, and we all had a jolly time.

Deep Canyon Dives at Cape San Lucas

One year after the La Jolla dives we were given the opportunity to join the scientists of the Navy Electronics Laboratory in their dives in Cousteau's saucer at Cape San Lucas, in the spectacular canyons that indent the sea floor off the southern tip of Baja California. Still later, in 1967, the Navy Electronics Laboratory obtained the use of Westinghouse's Deepstar 4000, and we were able to explore these same canyons to greater depths. The dives on those two occasions not only extended our observations to much greater depths, but also permitted us to see canyons that had been cut into hard granitic rock in contrast to the sedimentary rocks of the La Jolla area. In 1966 the Soucoupe allowed us to see the effects of the river of sand and sandfalls at the end of the Cape, which had been observed at a higher level by scuba divers. We found the floor of the canyon in this area had large ripple marks at 900 feet, with an abundance of fragments of rock that must have been dislodged by these streams of sand and the rocks had fallen from the walls onto the canyon floor (photographs). Surprisingly, the canyon head has a muddy floor and sand was found only as we followed the canyon

to about 1000 feet. During one dive along the steep cliffs we ran out of power and were somewhat alarmed at the prospect that dropping our ballast might let us come up under an overhang. Fortunately no such trouble developed, but Elizabeth, who was on the monitoring boat at the surface was worried. Later, in the Deepstar, Bob Dill and I made what was to me the most exciting dive of my career, going to just over 4000 feet in San Lucas Canyon. Elizabeth was again on the surface ship hearing all our conversation.

After two abortive descents in the Deepstar it was with some apprehension that we climbed down into the elliptical sphere and adjusted our legs into the somewhat cramped position, taking turns looking out of one of the small portholes. We were soon craned over the side and into the water, and saw scuba divers swimming around us, checking to see that all was well for our descent. Then, down in a spiral through the clear water with only an occasional fish, shrimp or siphonophore moving diagonally past the porthole. With the lights turned on, we saw we were passing through many changes in fauna, including one zone where life was very scarce; about 1000 feet (oxygen-free zone). Then at 3500 feet both fish and shrimp became increasing in numbers. The temperature outside dropped rapidly from 74°F at the surface until it reached 40°F as we approached 4000 feet and the bottom.

We landed on the canyon wall where a 20° slope was covered with a sandy silt and pock-marked with holes made by organisms. Brittle stars showed uneasiness at our approach and took off, moving through the water like frogs, their legs producing their motor power. Red shrimp peered at our lights and then swam past us.

We descended the small remaining side slope and after passing an outcrop of breccia, which had granite blocks of all sizes cemented together, we arrived at the canyon bottom, 4150 feet. A hard, flat sand floor greeted us. As we skirted over it we encountered zones with distinct large ripple marks trending across the canyon axis. Arriving at the far wall, we found a 5-foot vertical scarp that looked like mudstone and was definitely stratified. We took a sample with the mechanical arm and found the material was quite easily cut; apparently a fill of some old eroded, formerly deeper canyon.

Moving up the canyon axis we encountered many small blocks of granite that must have fallen from above. The currents were constantly against us and often slowed our 3/4-knot progress. Other evidence of downcanyon flows were the scour holes on the upcanyon side of the larger blocks of rock, and the dune-like ridges of sand on the downcurrent side. One hole had a trunk of a palm tree almost covered with small white living crabs. The floor kept changing from what looked like a desert pavement, or salt-covered sand berm, to extensive fields of ripples.

Suddenly to our left a great cliff loomed ahead of us. As we approached it, we saw it was a polished or smoothed mass of granite with an amazing pattern of zenoliths (inclusions of other igneous intrusive rocks). We could look up the cliff for what appeared to be 100 feet. Attached to the rock face were magnificent pink anemones with swirling arms adding color to the display. We all felt we had never seen flowers of greater beauty than those magnificent marine animals. Moving up the rock face we could see that the scoured, clean, eroded rock was replaced at about 20 feet by a more uneven and organically-encrusted surface. Irregularities were more pronounced in this upper

cliff -- gullies with steep sandfalls and grooves, apparently due to sediment sliding down the slope.

Coming back down to the canyon floor, we moved upcanyon along the wall. We found alternating right-angled contacts between floor and wall, with small sand cones or small gullies along the slope base. We encountered numerous blocks of granite on the floor and occasional small slump scars where the sediment had been moving en masse down the axis. We crossed the floor to the other wall, estimating the distance at about 300 feet. The east wall was also a smoothed granite, but not as steep as the west wall. Coming back across the valley we decided it was time to make our ascent. We moved up the wall and found, on reaching the top, perhaps 200 feet above the floor, a narrow ridge with a steep descent on the farther side. From there we continued through water to the surface, which we reached 5 hours and 15 minutes after starting down. Elizabeth was happy to see me emerge after those long hours of waiting on the monitoring surface ship. We had at least been in communication throughout the dive.

CHAPTER XIV: CURRENTS ON THE FLOORS OF SUBMARINE CANYONS

Dedicated to Captains Woody Reynolds of U.S. Naval Postgraduate School, and Garrett Coleman of Scripps Institution, both of whom threw all their energies into helping us to obtain some of our best records of currents in the submarine canyons. Their management of the small ships for this exacting work, and the fine cooperation of their crews was a notable reason for our success both in Monterey Canyon and in the canyon off Rio Balsas, Mexico.

Ten Years of Observation; Measuring the Currents, including Struggles with Physical Oceanographers, Lucky Breaks and a Narrow Escape

About the time that I found I would have to retire (at age 70) from Scripps Institution, I decided it was time for someone to really measure the currents in submarine canyons. Geologists had talked a lot about canyon currents and some theorists had the currents speeding up to 60 miles/hour, but no one had really measured them except by doubtful cable-break computations. I know this is the field that physical oceanographers should cover, but despite considerable urging from geologists, they had done nothing. I was no expert in current dynamics, and certainly was not good at developing instruments for the purpose. And I was now emeritus. However, my colleague John Isaacs and his associates had developed good current meters that could be dropped to the bottom as a package, and would return by themselves after a pre-determined release period, signalling by radio and flashing lights at night. I had several assistants who were good at things mechanical and they all quickly learned how to use the instruments. I had known where I wanted to get current measurements, and in spite of retirement I kept expanding my field until after a time, the world was the limit; actually West Africa and the Philippines were the most distant places where we measured currents in canyons.

There were, of course, troubles, and some current meters, each of which cost \$7000 or more, were lost from time to time. Also, they did not always operate properly. However, the ones that did work showed us all sorts of things that were previously unknown to science.

Among our hundreds of records we discovered things that I believe should have been known for years by the physical oceanographers, if they had only looked for them. For example, we found that almost all of the currents on the floors of the submarine canyons and other types of sea valleys are bi-directional, alternating between flowing up and down the valley or canyon floor, with alternations occurring at intervals that are almost always no longer than the time of alternation of the tides, which are so well known from tide gauges and observations of the sea along the coasts of the world. Next, we found where tides of average height, say 5 to 7 feet are found, the currents in the valleys show a clear relation to the tides, changing on the average of every 6 hours and 25 minutes wherever we placed our current meters at considerable depths - deeper than about 1000 feet. At shallower depths the alternations were much more irregular and of shorter periods. Next, we found that in areas with small tidal ranges, say one or two feet, as in the Caribbean or the Gulf of Mexico, the alternations of up- and down-valley currents become tidal in their relationship only at very considerable depths, on the order of several thousand feet, and that in the shallow valley heads the alternations were usually of very short period. On the other hand, where the tide range is very large, as off the Fraser Delta in British Columbia, the current alternations are of tidal period even in the very shallow portions of the marine valleys. Apparently it had never been suspected by the theorists among the physical oceanographers that such relations might exist.

We also began to find evidence of internal waves in our records made in submarine canyons. Physical oceanographers had known for some

time that internal waves, that is, waves that occur below the surface and are not related to surface waves, existed in the ocean, and that some of them moved progressively toward the shore from the deeper parts of the continental shelves. However, it never occurred to them that current meters placed at several points along the axis of submarine canyons might detect these waves. Our record showed patterns of up- and down-canyon currents that varied with time in intensity just like surface waves moving into the shore. We found that when we compared records from adjacent points along the canyon axes we could often find great similarities. The similarity was much increased if we shifted them timewise, generally so that, for example, a time of rather fast upcanyon currents observed could be correlated with a similar period of fast currents at a later time in a station that was up axis. This indicated that we were dealing with internal waves that were moving up the canyons. However, we found in a couple of localities that this matching was the other way around, so that the internal waves apparently moved down the sea valley or canyon. In such cases we observed that there was a source of water entering the system from outside. For example, a large river was coming into the sea at such a point, or a special convergence of wind waves was driving a mass of water in a direction of down canyon as at the narrows between Santa Rose and Santa Cruz Islands, where water is driven down the passageway by the northeast winds driving water from Santa Barbara Sound into the head of a submarine canyon at the strait.

The investigation of the bottom currents in the passageway between Santa Rose^a and Santa Cruz Islands gave us a real thrill. We had gone in

to Santa Rosa to pick up a surveyor who had been helping us get our positions in the channel using his instrument on shore, when a northwest storm condition developed. We had trouble getting him off the island in a small boat, as the seas in the Channel had begun to build to somewhat mountainous proportions. Someone suggested that since our 75-foot cruiser had capacity to speed up to about 30 knots, we should be able to ride the crest of one of the large waves that was moving down the Channel. We speeded up and had little trouble getting on a wave crest; pretty soon we were actually riding one of the great swells, moving rapidly down the slot between the islands.

What we had not counted on was that the big waves were far from regular and we soon found we were slipping into a trough with the awful sight of the next great wave bearing down on top of us. I had thoughts that the wave would swamp us and we would be sunk. We had no life boat or self-inflating raft to use in an emergency; our small boats were lashed upside down on the deck. Fortunately, however, the captain was a good seaman and, using every bit of power we had, we were able to get out of the trough before the wave broke on top of us. From then on we rode the crest successfully until the dangerous narrows were passed and we could turn and move along the shore of Santa Cruz to the harbor where we spent the night.

It was always amazing to see the meters come up at the designated time, due to their electronic clocks that dropped their weights at a set time, which allowed the floats attached to the meters to bring them back to the surface. We really did have a lot of good luck. Once we put the current meters down in the canyon off La Jolla, and while they were

down, a storm developed. When they were supposed to surface nothing happened, and we concluded that a turbidity current had carried them away. Some \$15,000, gone! By the grace of God, a few days later we had a chance to use a deep-diving passenger vehicle Nekton from General Oceanographic. We submerged at the place where the current meters had been emplaced and found nothing, so we traveled down the axis of the canyon. After about half a mile we saw a familiar piece of rope rising from a mass of kelp, looking like the rope that one might imagine a Hindu holy man uses to climb into thin air. Using the grippers on the outside of the diving vehicle, we caught the rope and exerted our full lifting power. Presto! Up came the current meters out of the kelp. When we returned them to the surface ship, the instruments and records were found quite intact. They had simply gone for a ride down the canyon, wrapped in a mass of kelp, and one of the floats had lifted some of the rope gear clear of the kelp: hence, the rope trick. We did not see the float itself because of the murk.

On another occasion the release did not work as expected, but after about 20 days, the weight was freed from the current meters, perhaps due to slow wear by currents along the bottom, causing the rope to part; the current meters returned to the surface and luckily the local Coast Guard spotted the buoy and brought the meters in and notified us. One of our meters was picked up by a fisherman many miles from where we had dropped it. He saw our Scripps Institution label on it and persuaded the cannery where he brought in his fish to notify us.

The first free-vehicle devices to be developed used magnesium releases. With those we could not predict the time of surfacing

very accurately, but usually someone would spot it anchored by the trailing ropes in the shallow water near the beach, let us know, and we would recover it. It was amazing that we had so little loss in those days.

Perhaps the most spectacular recovery was from the Congo Canyon area off West Africa. We had gone to Africa especially for this operation as guests of Woods Hole Oceanographic Institution, on their ship Atlantis II. We saw the current meter come up on schedule but there was a strong surface current, and the first pass made by the ship to pick up the meter failed. It was very close to a shoal and the ship's crew tried a grappling hook -- made a fine throw which netted it but, to our horror, no one had fastened the line to the ship. The current meter drifted rapidly into shallow water; it was getting dark and the small boats were not working well, so we had to stand by all night (little sleep for me), before the captain could risk sending a small boat after the meter, into the shoals. The next day, either the radio or the current meter had stopped transmitting, or else we were too far apart to hear it. We went offshore around the shoal and up the coast for about 40 miles in the general direction of the prevailing northwesterly ocean current and, to our joy, heard the faint "beep, beep" of the current-meter radio signal. We couldn't see anything, but were able to estimate on which side of the deckhouse the sound was more intense, and headed in that direction. We soon saw the flag and picked up the meter, this time with no trouble. The current meter had stuck on the shoal twice, as we could tell from the record, but each time waves had apparently broken it loose and the strong northwest current had taken it in tow. All was in good shape; our trip was not in vain.

After several years of operations with the current meters, our excitement was immense when we at last began to obtain records that we were certain were made by the elusive turbidity currents that no one had measured previously, except for very short periods before the current meters had been lost. These currents were not nearly as strong as those 60-mph currents that theorists had been predicting for ^uturbidity currents. We recorded only a couple of miles per hour, but the records were clearly different from the usual currents that exist in the canyons. We determined that they occur quite frequently in areas where rivers are carrying large quantities of sediment into the ocean near the head of a submarine canyon. That made our rather expensive project well worthwhile, at least so far as geologists are concerned. Thus it did not prove to be one of Senator Proxmire's "boondoggles."

One of the strange things about this whole project has been the real difficulties we have had with some physical oceanographers. Perhaps it is not so strange, since our reports have been written for geologists, and have not included the type of lingo that is used by physical oceanographers. We have tried to persuade them to work with us, with some slight success, but only from those with a geological background. The rest of this group seem to find all our numerous records confusing and contradictory. They seem to prefer to base their theories on small samplings which we geologists would consider woefully inadequate. Of course, we do have a lot of trouble understanding their theories, as they are couched in mathematics and physics and are somewhat beyond the understanding of most of us. The simple things we observe just don't have much appeal to these learned gentlemen. Is it our stupidity, or are they just not willing to confront nature in the raw?

Getting Cleared for Mexican Operations

In the good old days, that is, before 1970 it was quite easy to get cleared for scientific operations in Mexican waters. Maybe that was before it was necessary to do anything but clear the ship for entry; and sometimes even that was not done properly and the local port authorities made it rather unpleasant until a few gifts were made and apologies offered. One time our swashbuckling captain invited us scientists to dinner at a resort near Cape San Lucas, Baja California, but something was not in order and the port authorities caught up with him just as the meal began. While the rest of ate an elegant dinner, he procured the proper papers to continue. He kept out of a Mexican jail by a small margin and plenty of under-the-table maneuvers.

About 1970 our State Department and the Mexican government began to throw red tape into the picture. We started well in advance to get clearance for an overland trip along the new highway down Baja California to Cape San Lucas in a carryall with a rubber raft on the roof, and our equipment for taking current-meter readings in some small submarine canyons along this coast. We had our provisions ready to go; tents and food, and were told that permission was all but granted. Then the day before we were planning to leave we received a form letter from Mexico City which simply said, "Permission Not Granted." There was no explanation, and nothing we could do! Our State Department would take no action; there was no help. We just did not go.

In the spring of 1975 we had been given permission by Scripps Institution to use the ship Ellen B. Scripps for a month to work off the Rio Balsas Delta on the west coast of Mexico. We were determined not

to have any trouble this time so we started a year in advance, going through all the State Department formalities, and had Mexican scientists and U. S. scientists living in Mexico City helping to get everything arranged just right -- or so we thought. Time passed and the only thing we obtained was assurance that there was no opposition in Mexico, and that the engineers of the new harbor at the mouth of the Rio Balsas, Mexico's second-largest west coast river, were most anxious for us to do the work so that they would know more about the area at the entrance of their harbor.

As the time of departure approached and we had no word, we began to get worried. We had the cooperation of the U. S. Geological Survey, who were providing a panel of instruments built into a mountable deck lab, and several scientists to operate them. Former Scripps student, Erk Reimnitz, and some Mexican participants went ahead to meet the ship and install shore stations for our locations. There still was no answer on the work permit, although our ship had an entry permit. Some friends in Mexico City urged us to start down the coast, saying we could at least operate beyond the 12-mile limit while the final clearance for the project was being approved. We finally did just that. We arrived at Rio Balsas and picked up two Mexican scientists and three members of the U. S. Geological Survey at the river mouth, but still no permission. Erk Reimnitz spoke fluent Mexican Spanish and went ashore every night to telephone Mexico City to see what was happening. Finally even the U. S. Ambassador tried to aid our cause.

After working beyond the 12-mile limit for a number of days we decided, "This is enough of outside work; tomorrow we return to San Diego."

We radioed that decision to the Mexican authorities and told our friends onshore at the port. Just as we were about to start for home a radio flash, and permission, came in. The officials finally stamped the papers with the permission granted.

We started a fast and furious 10 days of work, crowding all our program into that amount of time. Almost immediately we made one of the most exciting discoveries of my career, measuring a complete turbidity current with a current meter, never before accomplished. The meter was located in the canyon directly off the mouth of the Rio Balsas.

CHAPTER XV: THIRTY-FIVE ISLANDS OF MICRONESIA; CARMARSAL EXPEDITION

In memory of our friend Harry C. Patstone, chief engineer of the Horizon during the Carmarsal Expedition. This man was an inspiration to everyone on the expedition, not only because of constant and cheerful attention to duty, but also because of his example, constantly helping the natives of the islands we visited with such practical things as water pumps. On retirement he obtained dental technician training and a plane and began touring Central America, setting up volunteer clinics to help people care for their teeth. Unfortunately his plane hit an obscure wire and this fine man died in the accident.

As a result of our work on the northwest Gulf of Mexico, Joe Curray and I became very much interested in the history of sea level rise at the end of the glacial period, and particularly the level during the last 5000 years. Professor Fairbridge of Columbia University, and many others, had been advocating that sea level had stood at least 10 feet higher than its present level for a portion of this relatively recent period. They gave many examples of terraces of relatively recent date that supposedly favored this concept. However, the geologists working in the northern Gulf of Mexico were equally certain that no such high stand could have occurred, and the work Joe Curray and I had done in that area seemed to indicate that sea level had risen slowly during the last 5000 years; there was no indication of any high stand in post-glacial times.

We decided it would be a good idea to have an expedition to an area considered to be a stable portion of the tropical Pacific, to see if we could find raised coral reefs among the islands such as should exist if the sea had indeed stood higher in these relatively recent times. We chose as a test area the Micronesian islands of the Caroline and Marshall group that are entirely to the east of the Mariana Trench, where there is no evidence of recent vulcanism or of earthquake epicenters to indicate instability. We wanted to have experts in the study of coral reefs, marine terraces and coastal processes with us, and tried to get scientists whose opinions about the controversy of recent sea level changes were somewhat conflicting. Thus we were able to get Norman Newell of the

American Museum of Natural History and Columbia University, an authority on coral; A. L. Bloom of Cornell University, a well-known student of sea level changes and marine terraces; Joshua Tracey of the U. S. Geological Survey who had studied many of the reefs of Pacific islands; ^{William} W. A. Ne^wman of the Scripps Institution, a biology professor who specialized in coral ecology, and H. H. ^WVe^eh of the University of Hawaii who had become an expert in dating organisms from ancient reefs.

We obtained a grant from the National Science Foundation for the expedition. Elizabeth and I flew to Guam to join the Horizon in February of 1967, joining the other scientists and assistants there. We spent a day examining some slightly elevated coral reefs of the island which were described earlier in the literature. Guam is on the active west side of Marianaⁿa Trench and has had a very different history from the islands on the east side, which were our target.

^{Setting} ~~Setting~~ off a couple of days later with a crew of 17 and a scientific party of technicians; scuba divers including Jimmy Stewart, who was in charge of SIO's diving program; a doctor, and Elizabeth who was the only lady in the group of 15. We rounded the south end of the island and headed into the easterly swells. We soon began to get requests for seasickness pills as the motion of the ship became more and more violent; most of the scientists did not have their sea legs yet. Fortunately, no one proved to be a serious victim of the malady.

We crossed the Marianaⁿa Trench, where the depths are so enormous that the echo sounding equipment on the Horizon failed completely to obtain any record. After all, that is the deepest trench in the world, and our crossing was not far from where the deep spot was discovered.

We originally intended to make a scuba dive on what appeared to be a slightly submerged atoll, but the sea was too rough for such an operation, so we headed for the island of Ulul in the Namonuito Atoll of the Caroline group. We were not sure that this would give us enough lee to anchor and land, nor were we sure whether the island was inhabited. Presently both questions were answered.

After two days of crashing into the headseas of the tradewind which were unusually large, we sighted the tops of palm trees on the horizon. Gradually the low islands came into view, and through the glasses we spotted thatched-roof huts and patches of reddish color which turned out to be the abbreviated costumes of the natives. The seas began to calm down and we found we had a good lee for our landing operation. The natives swam out past us, diving around the ship; others came out in piroques, dugouts with outriggers. Following is an account of our reception by the natives of the island.

Island of Ulul of Caroline Group [by Elizabeth]

When we came into the protection of Ulul, we were greeted by the sight of an island feathered with coconut palms and breadfruit trees, wearing its fringing reef like a necklace. The water varied in color from all shades of turquoise to indigo blue. The island is about four miles long and half a mile wide, with a break in the reef next to the shore that was natural, but was widened to about 15 feet. Our approach was alive with dark youngsters sporting in the channel to reach the outer reef. No swim fins were necessary for these little swimmers, and there was much splashing and diving with feet in the air, coming in over the reef without the need of face plates.

On shore we saw two large boathouses and people crowding the beach to welcome us, all wearing dots of red cloth. Three piroques made of breadfruit tree wood, and outriggers consisting of hibiscus branches, were paddled out to meet us, filled with excited smiling natives and one white boy, a member of the Peace Corps. They came aboard and we received permission from the chief to go ashore. Fran, the captain and I were landed first, greeted by the chief, and taken to the boathouse. I was met there by a dignified elderly woman who very majestically led me to the village, which consisted of open-air huts and slightly raised shelters with thatched, peak roofs. There were many small dogs and wild chickens (finders keepers for their eggs), and a few birds.

The women and children surrounded me, watching my every move; they touched me, felt my white hair and pointed out my freckles; naturally, they had none. All these people seemed healthy and happy and relaxed. I saw no cripples or spastics, and only one white-haired man. They sang for us and we recorded the songs on tape. As we played it back for them they laughed uproariously as they identified different voices.

There were two Peace Corps boys on the island, who ran American movies for the islanders, who particularly enjoyed westerns. The island religion is Catholic and they have a coral-floored church which would hold about 75; no doors or windows - just openings in the wall. I got the feeling that Catholicism was practiced only when the priest was in residence, and that their own religion of many years was still leading them in their peaceful, honest ways.

Their costumes varied, but consisted mostly of breech clothes for the men, nothing above the waist for the women, and the children were

just as nature made them. Their diet consisted of breadfruit, with its lovely leaves, sugar cane, yams and, of course coconut and its refreshing milk. They eat fresh fish and octopus, but not slugs or sea cucumbers as some other islanders do. Their noon meal is usually rice provided by the U. S. Territorial Administration which is served at both schools.

School goes through seventh grade, and there were three high school graduates who had gone to school in Truk. One boy was a graduate of the University of New Mexico, and wished to come to Scripps. The girls made me hibiscus and blue trumpet flower leis, and the chief gave me a fine lei of cowrie shells with dyed hibiscus fibers. We exchanged colored beads, pens, fish hooks and gum for shells. The natives share their gifts with all. I very carefully presented the chief and his wife with a Kennedy half dollar on a necklace and later saw it on a small child.

One morning when I came ashore about twenty women were plaiting palm fronds for a new roof -- the fronds brought up by truck, believe it or not. I gave each weaver a string of beads and they all passed them on to their young. One Sunday we were invited to a stick dance. Twelve of the boys around 15 years old dressed in banana leaf skirts and crowns of flowers did an animated step to a chant, with elaborate turning and hitting of sticks. We were told that the women had not danced since Catholicism had come to the island 25 years before (the chief had asked the women to practice a dance for us). The captain, through the island chief, invited the women to come out to the ship.

After a quick dip, clothes and all, I rushed back to the Horizon to prepare for the party. When we were ready for them, with the Coke

machine operating and boxes of cookies, we were at first afraid nobody would come, but come they did, swooping down like a cloud of locusts. Four of us fed dimes and nickels into the Coke machine, opened Cokes, and filled large bowls with cookies. The guests were seated in the mess hall and the bowls of cookies were emptied immediately, either eaten four at a time, or put into paper napkins to take ashore. Three 8-lb packages of cookies disappeared in 20 minutes. They also sampled the condiments on each mess table, the mustard, soy sauce and ketchup.

I took the women, in four groups, into our stateroom where they tried the bunks and made faces at themselves in the mirror. After we had served 100 or more women, the children came, and then some of the men. They swarmed all over the ship, even trying the hammock on the fore deck; the children dove off the upper deck and raced up and down the passageways. When they left, we cleared up the "mess," and it was a mess.

Before the chief of Ulul left the island to attend a conference on another island he dined on the Horizon, and gave orders for the women to practice their old native dances so as to perform for us at a luau. The entire ship's complement was invited to attend at 4:00 p.m. The work program for scientists and crew was adjusted so that all could attend except the ship's watch. The island was a beehive of activity in preparation; they were unbelievably organized, with each person quietly and leisurely doing his or her job. We made punch in new 5-gallon garbage pails and took our largest trash can (well scrubbed) for the punch bowl; we also took apples. The crew and scientists wore their best ironed shirts and I wore a dress and an orchid in my hair. As we landed we were

met by the one island truck to transport our part of the refreshments to the school house in the middle of the island, equally distant from the three small villages.

After an informal greeting I was asked to start the food line to fill my banana-frond plate. There was fish, large ones smoked and baked; small, deep-fried whole ones, heads and tails included; bread-fruit, sliced and baked, as well as pounded and cooked in a coconut sauce; baked bananas, boiled papayas, octopus, looking very much like live octopus, and wild chicken, the only tough morsel there. The men waved palm fronds above the food to chase away the flies -- in fact, only men served, dressed in breech clothes of various materials. The porch of the school was carpeted with palm fronds and we were seated on the floor, using the wall of the school for a back rest; it was a comfortable seat. We used our fingers and were each given a fresh coconut to drink. Each guest was ceremoniously crowned with a wreath of flowers, grass or vines -- no two were alike -- and each wearer took on a rakish air. One older woman took a fancy to Harold, our electronics expert, and dramatically came across the stage to place a wreath on his head. When we finished eating, our eating baskets were collected and used again by the men, who filled them with so much food it was unbelievable they could consume it all. No women or children came to the table.

The dancing women approached slowly and majestically from the other side of the island, dressed in skirts of bana leaves decorated with flowers and a variety of grass garlands, again no two alike. Most of the women were topless, but two were wearing white bras, dazzling against

their glistening brown skin; one bra had holes cut to facilitate nursing. The dances they did to chants were love dances, quite restrained except for one animated clowning middle-aged woman who gave it her all with rhythm and gusto. Most of the women, all of whom were married, wore rather sad and dreamy expressions in great contrast to the men who danced later and enjoyed their dancing as much as we did, with their lively, noisy, body-slapping performance. One three-year-old was unhappy to have her mother performing and began to howl, but she was consoled by the other children.

After the women performed their restrained dances they joined the audience, giving their grass skirts to the men. The men approached with glee and animation, enjoying the response from the audience. They did about ten dances, each spontaneous, decided onstage after much discussion: dances of navigation, war, and love, all performed with vigor, complicated footwork and rhythmical slapping of arms, body and thighs with gloves of palm leaves which made more noise than their shouts. During the performance people moved quietly about. Three little 3-year-old boys did a pantomime of their fathers, and three other little ones crowded into one discarded skirt and walked around, tripping and stumbling. The children were unrestrained by adults, sisters or brothers, and were all very well behaved.

After the dancing our supply of apples and punch was passed around and we all mingled together, my favorite women and girls coming to shake my hand -- not an American handclasp, but an interlocking of thumbs.

As I explained we would go away in our boat for a few days, to return later and pick up the men left ashore drilling a well, one girl

turned to the others and explained in French to the other girls in her group. This group was probably from one of the other islands, come to attend the school in Ulul. We slowly drifted back to the beach and came aboard our floating home happy and contented.

[back to F.P.S.]

The scientific study of Ulul began to set a pattern which continued for the rest of the trip. We found an abundance of blocks of coral well above sea level, up to about 6 or 7 feet, but never did find a raised reef with corals in the growth position. The blocks were clearly ones that had been thrown up by waves such as might be encountered during present day storms (photograph).

When the tradewinds gave out for a few days we returned to the deep-rimmed bank and our scuba divers descended to look for signs that this bank might have subsided. Again there was no indication of any relatively recent change in level from what we observed. The sharks were somewhat of a menace to the divers and we lowered a cage so the divers could get in, if necessary. No aggressive moves on the part of these unpleasant fish were encountered, so the cage was never occupied, even by the sharks. They were around, and some of the divers kept their spears pointed at them in case they got aggressive. One of our scuba divers had had an experience with a shark several years previously, and shows the scar very clearly on his left arm. His attack came when he neglected to watch a shark which he had been photographing and it came up behind him.

Truk Lagoon

Scientifically, our most important investigation during CARMARSAL Expedition was the visit to Truk Lagoon. If we had been there 22 years earlier, we would have encountered one of the greatest air-naval battles of history when the American air forces attacked and sank a major portion of the Japanese fleet that was bottled up in the Truk Island stronghold. The Japanese had fortified this area extensively before the war, in direct violation of the 1919 peace treaty agreements.

Truk includes a series of beautiful high islands surrounded by a huge blue lagoon, very peaceful after the stormy seas on the outside. It is 30 miles across and has a circular barrier reef at the outer margin, the latter studded with numerous small atoll islands rising a few feet above sea level. It is accessible by a number of passes. Inside the huge lagoon the barrier has an abundance of reefs; it was surveyed by the Japanese in prewar days, with extraordinary accuracy and detail and our Navy acquired the charts after our 1945 victory. Throughout the Pacific islands, only at Eniwetok in the Marshall Islands are any other surveys as complete.

I had always been told by my friends in the Coast and Geodetic Survey never to trust a tangent of an island for use as a means of location. Truk Lagoon was an exception. With a sextant and one horizontal angle I could get a peffect location where the tangent of one island ranged on that of another. I just took an angle to some other point from this range. This proved far better for locations than the excellent radar which the ship's officers were using. So far as we could tell, the Japanese charts showed accurately every point and curve in the island shores.

Truk was the second major target visited by us, and followed closely on our delightful time on Ulul. Despite our very hospitable reception at the various inhabited islands of Truk, notably Moen, the main center of administration of the territory by the United States, under United Nations charter, we felt some disappointment. The natives seemed to have deteriorated badly from their contact with civilization. Especially on Moen they impressed us as lazy and listless. "Why should we fish when we have so many handouts from the government?" Some of the school children were an exception, partly because they came from other islands, visiting Truk for their high school education. The boys delighted us with a gift of a model outrigger after I gave a talk at their school. Elizabeth, to her surprise, was asked to talk to a group of girls. In some perplexity as to what to say, she asked them all their names. They gave her first names only, and she recalls the following: S.O.S., A.M., P.M., Lazy, Shame, Lover, Two Loves, Bird and Fish.

We happened to be at Moen when the delegation from the United Nations came to inspect the Micronesian trust territory. They visited us on the Horizon and we enjoyed talking with them. Unfortunately, they seemed to want the U. S. to give more to the natives, when we felt that what the U. S. really ought to do was given them less and get them back to work. The head of the delegation was a black lady from Liberia with a majestic personality, quite dictatorial in a charming way, and she was certainly impressive.

We visited Fefan Island where the Japanese had their wartime headquarters. It was almost completely overgrown with vegetation. We could hardly see any evidence of the old fortifications. Out in the

waters off the island there were many masts sticking up at rakish angles from old sunken Japanese vessels. Our scuba divers descended onto one of them and acquired some souvenirs from the coral-infested decks.

We talked to a few Catholic priests who still live there in their mission, and they told us they knew the Japanese were rearming the island well before the war, but no one could get the story out because of the extreme secrecy. They actually continued to conduct their Catholic mission during most of the war and were interned only just before the Japanese suffered their great naval defeat. The priests had their own story concerning Amelia Earhardt, to add to many other legends. They say she was captured and executed on that very island.

Our scientific studies indicated that Truk Lagoon had never suffered a higher sea level in post-glacial years. We found no raised reefs. We also got good evidence that several deep holes in the floor of the lagoon represented sink holes formed, most probably, when the sea was much lower, during stages of maximum glaciation.*

Ponape and Ruins of Nan Madol

During the Carmarsel Expedition there was but one attraction among the 35 islands that we visited that caused universal enthusiasm among all members of the crew and scientists. Surprisingly, it was an archaeological ruin. Elizabeth had read that Nan Madol, located on the windward side of Ponape Island east of Truk, had the most remarkable ruin in all Oceania. It has been called the Venice of Micronesia. At

* Curray, J. R., 19____
Shepard, F.P., 19____

first the crew complained, "Who wants to see some old stone ruins?"

Elizabeth and I were put ashore at Matalam Harbor near the ruins. We were welcomed by the priests of a Catholic school which is actually financed by the policemen of New York City. The locals filled us with enthusiasm for a visit to Nan Madol and told us that the approaches had recently been cleared of excess overgrowth in preparation for a visit by UNESCO, so our small boats could get there easily at high tide. We returned to Horizon and persuaded the rest of the scientists and the captain to join us for the visit. After traversing some reefs and shoals along the coast for a couple of miles, pushing and poling our way through the very shallow places, we could see ahead of us some walls rising above the low coastal marshes. We were amazed to find great blocks of columnar basalt laid on their sides and stacked up to 15 feet or more, enclosing rectangular courts. We estimated some of the blocks to weigh as much as 35 tons. They were fitted together as though with great care in their construction. How could the ancient natives bring those huge blocks all the way around from the other side of the island, where there is a volcanic neck that could be the source? They must have lashed together many canoes for the transportation, and they must have had very competent engineers for the whole project. There was a series of these rectangular structures, some of which were now in the shallow water beyond the reef edge.

When we returned to the Horizon we got the crew interested and they gradually all went to see this remarkable feature and shared our enthusiasm. The area does not have the remarkable carvings of Easter Island, but the blocks transported by these ancient natives were certainly much larger. The rock, being hard basalt, was not good for carving.

Kusaie and the Sunken Pirate Ship

The last high island of the Caroline group which we visited was called Kusaie. We had been told that here we would find beautiful examples of raised reefs of low altitude. Superficially this opinion appeared to be correct. We could see truncated inclined beds that certainly looked as though the sea had in recent times stood higher. However, on closer examination we failed to find a single example of reef rock that had grown in place at a level higher than the tides, which had a rather considerable range on this island. What actually emerged, as on the other islands, was indications that storms had built up masses of rubble with a relatively flat top, and this rubble had later been cemented so that it looked to the uncritical eye, like an old reef.

One harbor where we anchored had a special fascination for the scuba divers when we learned that the pirate, Bully Hayes, had been anchored there when the island was struck by a hurricane. His ship was sunk, but he and his scoundrel crew got ashore with their weapons and took over the local town. They enslaved the natives for a number of years, but finally got an opportunity to escape the lonely outpost when a ship finally put in at the harbor. However, during the voyage that followed the ship's cook somehow learned the identity of the pirate and, when he found him alone on deck, he attacked the pirate with a meat cleaver and threw his carcass into the sea. The natives, meanwhile, were overjoyed to be free once again to carry on their peaceful existence.

Our divers found the old wreck and made a descent on it. They recovered some interesting relics which we now have preserved in the museum at Scripps Institution.

Another interesting experience during our stay at Kusaie was joining Art Bloom in his attempt to follow some of the streams that flowed out of the marshy terraces around the island, in order to take cores of the underlying formations. As you leave the coral-fringed coast, you move into a dense mass of vegetation palmettoes and mangrove. It seems almost impossible to find such a lush swamp right in the midst of coral islands. It was a spooky feeling. When we found a place where we could take some cores, it was a surprise to find shells and indications of beaches at a short distance below the surface. Again however, no evidence was found that the sea had stood appreciably higher in the past than it was at the present time. The levels of these beaches were somewhat below present sea level. Taking these cores in the swamps, with no tradewinds to cool our bodies, was a pursuit that was anything but pleasant and it was a great relief to drift down the sluggish streams to the open coast and encounter the cooling tradewinds again.

CHAPTER XVI: HUNTING FISH BY CAMERA ON CORAL REEFS

In memory of my friend Ron Church whose remarkable underwater photographs were a great inspiration to professional and amateur photographers alike. He was an excellent pilot of underwater craft, notably the Westinghouse 4000. Unfortunately, he died quite young of a brain tumor, but his widow provided us with an exhibit of his photographs and some moving pictures shown at the Scripps Museum.

I seem to have none of the instinct supposedly inherited from our ancestors, who took equally great joy in hunting their enemies and their game, such as Teddy Roosevelt, who liked nothing better than shooting big game in Africa. I suppose my lack of interest in hunting and fishing shows an inconsistency, as I am not a vegetarian, and especially like to eat fish that someone else has caught. But to swim on a beautiful coral reef where the colorful fish move peacefully around the coral fronds and graze on the bottom vegetation, apparently with little animosity toward their fellow denizens of the reef, except perhaps to warn a passing fish that it is intruding on their proscribed territory and that it should feed elsewhere -- to enter this community with a spear gun does not appeal to me at all. Particularly disgusting to me is the fisherman who boasts that he never eats the fish he catches, and often brings in big fish that he knows will not be eaten, but will make a fine photograph with him standing next to it, or it will look impressive when properly mounted on a wall in his den. Is that really very much different from ancient men who showed rows of skulls of their victims that they had killed?

After swimming for many years with a snorkel and face plate, marveling at the beauty of what I could see with very little submersion below the surface, I decided it was time I began to take photographs of the beautiful scenes that are virtually impossible to see from a boat, and very hard for a swimmer to distinguish without a face plate, or even

from a glass-bottom boat. The early cameras were so complicated, and presented such difficulties with water-tight cases in which to insert them, that it took someone more mechanically inclined than I am to use them with much success. I did try a few.

However, with Cousteau's Calypso camera, which later became the Japanese Nikinos, it was a simple matter of placing the camera cord around your neck and jumping into the water. It had controls that could be operated for shutter speed, distance, and aperture, all by small thumb screws. We had one for our scientific work in scuba dives and used at depths where the results were generally quite disappointing due to fading of color with depth.

I borrowed the Calypso camera for one of my vacation trips. Going to Moorea and Bora Bora at the Club Méditerranée provided a wonderful opportunity to take photographs in the clear water around the reefs. I obtained some pictures of the corals which I used to illustrate chapters in my books about marine geology (photo). I was, and still am, an amateur. The field is full of real professionals, but this is true also of those of us who enjoy taking photographs of land scenery. We don't expect to win any prizes.

The real trick to underwater photography is getting the fish to pose properly for you. Generally, you have to sneak up on them with very little disturbance of the water. The right kind of bait will often lure them into the picture, but don't just spread pieces of bread around; they tend to float on the surface and disintegrate. Turning over a rock is sometimes quite effective in bringing in clouds of fish, but will also expose a lot of organisms and is bad for the ecology. The rock should be returned to its original position after taking the photographs.

You do not have to be an Olympic type swimmer, or, let's say a Cousteau type, to photograph the antics of various remarkable sea animals. While swimming in the Galapagos Islands I was at first startled to see a sea lion (I guess you could call her a lioness) come up alongside me, apparently to get a good look. From then on, while I was in that area I was ready with my underwater camera, and was able to get a few shots as the sea lions dove past me, perhaps admiring my special type of face mask. They generally moved so fast that I got only their tails in my photos, but some moved slowly enough to let me get a decent shot.

The strangest combination shot I got was while swimming near shore in the Galapagos Islands. As I surfaced I saw on the rocks one of the small penguins whose ancestors had followed the west coast of South America up from the Antarctic in the cold Humboldt Current. Shaking the drops of water from my camera I took a photo, then turned seaward, swimming out to the reef beyond. As I glanced to one side, there was my penguin, swimming right past me underwater. I took a quick shot and managed to catch the bird in his aquatic environment.

One always thinks of large fish as the attackers of small fish, rather than their friends, but this is not always true. The 'cleaner fish' go right into the mouth of large fish and, instead of being devoured by them, they are cleaning them of parasites. There are actual cleaning stations where this goes on. Also, relatively large fish often swim next to small fish, both following the same pattern. This is probably so that the small fish can eat what the larger fish discards, as is the case of the remora and the shark, to which it attaches. This also applies to some of the reef fish where they graze on small organisms growing on the rocks.

In ancient Hawaii there were areas where natives, having committed some tabu, could go to; a place called a City of Refuge, and the native chiefs could not touch them as long as they stayed there. I found a reef area off Kauai, in the Hawaiian Islands where the fish seem to have the same arrangement. They would come in droves into the shallow water and stay there feeding, often letting you get very close to them without showing any sign of disturbance. I even saw one blue jack about two feet long in such an area who positively refused to pay any attention to me. I followed him for ten minutes, virtually touching him, but he continued grazing around a large rock, as if I were not there at all. Of course I did not have a camera at that time. One trouble with the area is that small waves break gently over your head, putting a lot of bubbles into the water and stirring up the sand, so photography is not at its best. Fast film seems to be most satisfactory at such a place.

Most amateurs are somewhat terrified by encounters with ugly-looking fish such as barracudas and moray eels. They do look terrifying and there are cases where people have been bitten by both these types, but so far as I have learned from many friends who are ichthyologists and know about these fish, they are of very little danger when they can see you in clear water. The danger, evidently, is when they just get a glimpse of a hand or a foot in murky water. I learned to swim with numerous barracuda circling round me in the reefs off Belize (formerly British Honduras) and became completely used to them. They are curious and I have often had them follow me right in to the beach, but if I turned toward them, they would generally swim away. Morays have a way of opening their jaws for breathing that makes them look vicious, but they apparently won't come out of their holes in

the reef to attack a human, and largely inflict bites only when a human puts his hand under a rock or into a crevice where the moray is living. The beautiful lion fish and the ugly stone fish are the really dangerous types, and then usually only when they are disturbed in their hiding places, or when someone steps on the camouflaged stone fish. Their spines have a very venomous poison which causes intense suffering and even death, but antidotes are available.

Sharks are, of course, a danger to swimmers, but this has been vastly exaggerated by that awful dramatic movie "Jaws." Probably nothing has done more to discourage what is perhaps the finest and most healthful sport of all -- swimming -- than that book and the subsequent movie. It made millions for the author and more for the producers, but it stopped millions of people from enjoying their swims. Considering that there are actually many hundreds of millions of people who swim every day in the ocean, and that sharks exist in most of these places, is it not significant that shark attacks are so rare as to make headlines in the newspapers when they do occur, and that most victims survive? If you are a swimmer, you are much more likely to be hit by lightning on land than bitten by a shark in the ocean, and your chances of being injured or killed by an auto must be a hundred times greater than by a shark. Who gives up driving or crossing streets, despite this far greater danger?

I do believe that we should avoid playing around with sharks as some swimmers do. And trying to get up close to get a photograph is a foolish risk, as one of my friends, Jimmy Stewart, our chief diver at Scripps, found. As mentioned earlier, his companion, Ron Church, got the photograph all right, and Jim has it on his desk -- but after Ron shot the photo, Jim had the feeling that something (cont. on next page)

was behind him and looked back, raising his right arm just in time to encounter the teeth of the shark that was attacking him from the rear. He lost a lot of flesh from his arm, but the shark, unlike stories of the danger of fresh blood in the water, did not return. Jim's diving partner, Ron Church, got him ashore and after an emergency flight to Honolulu from Wake Island, and considerable surgery, he is now fine and continues to be our chief diving officer. One might conclude from all this that sharks are best not played with, but they are not such a menace as to keep people from swimming in most areas, even if sharks are occasionally reported.

CHAPTER XVII: FRIENDSHIPS WITH STUDENTS AND EMPLOYEES

In these days of bitter fights between employees and employers, it may be hard to believe that someone could have had such friendly relations with those whom he employed as has been my good fortune for many years. Of course, this relationship had a fine start 'way back in my University of Illinois years when I was fortunate to have brilliant students like K. O. Emery and Bob Dietz funded on National Youth Administration grants during the depression years. Most of these students and associates became life-long friends as they continued into their outstanding scientific careers. Elizabeth and I feel like parents to many of them. We had several of our students live with us during their student days.

During the war, in addition to some young men who went to sea with me and also did laboratory work, I had the new experience of having a group of three or four young ladies helping me with the making of color maps for the U. S. Navy, showing sediment distribution on continental shelves in enemy territories of East Asia. One of them, Jane Dinkins was smart as a whip and worked rapidly at what she was assigned to do; her example, and pleasant disposition proved inspiring to the others so that, despite some usual girl gossiping among them, they went right ahead and accomplished their assignments in record time. We all became good friends. In fact, now, more than 35 years later Elizabeth and I get Christmas cards from some of them and see them occasionally, though they live far away.

Coming to Scripps Institution after the war, I was fortunate in employing as a secretary-assistant a girl by the name of Ruth Young. Ruth had a brilliant mind in addition to a very pleasing personality. She did not have much education but began taking, or auditing courses around Scripps Institution, in order to help her understand some of my problems. I recall that she took a course in statistics in which her examination paper was considered the best in the class, despite the other students all being graduates. She soon became a research assistant and was excellent in both field and laboratory work. She worked with me for ten years, the last three of which she was married to our publicity manager. To the great sorrow of everyone who knew her, she died of cancer.

I have been most fortunate in secretaries. They have all helped my work tremendously. Following Ruth were Betty Sanborn, Margaret Miller (wife of the well-known author Max Miller), and Nance North, well versed in Scripps Institution activities and, like Margaret, very capable in criticising my manuscripts, and also excellent in staff relations. They all became close friends to us, and kept the office going during my absences on my many trips. My secretaries at Scripps were also good friends with Elizabeth. She often remarks on how they would telephone her at home when they noted I was having a particularly good conference with a visitor, and say, "Elizabeth, you better be prepared to have a guest for lunch (or cocktails)," and Elizabeth would get something out in preparation for my last minute call: "Do you mind if I bring so-and-so up to the house this noon (or evening)?"

There is no doubt but that my rather prolific writing was to quite an extent the result of the good correcting and copying of my secretaries, and to their many suggestions for improving my style. I should not blame them for my being a poor speller, just because they were all so good and used a dictionary when in doubt. Margaret Miller used to give me lists of words which I habitually misspelled, and that did help me some.

One of my former students says he does not need a draftsman to assist him; he can do his own illustrations perfectly well. That does not apply to me. It is hard enough for me to make even crude sketches to show my draftsmen what I have in mind. In this respect I was lucky in employing Donald Sayner as a draftsman when I began API 51. Don was a natural and drafted for me very satisfactorily for several years, until he had to move to Arizona for his health; there he soon started to teach mechanical drawing at the University of Arizona, and still does. We miss him. Don trained another young man, James Moriarty, a war veteran who worked for me for many years, and illustrated many of my books. Jim became more and more interested in archaeology and finally became a member of the faculty of the University of San Diego in that field.

In connection with my studies of the currents of submarine canyons, I have had three assistants: Neil Marshall, Gary Sullivan and Patrick McLoughlin. Neil was with me for a number of years before I got started in the current meter studies and worked into it. The other two, both Vietnam veterans, acquired the skills rather quickly. There is no doubt that the report on our results⁶ would have been impossible without their expertise in using the instruments, and I feel that just because I did most of the writing and theorizing, they played an equally important role,

and hence are included in the authorship. Actually, Pat showed considerable good sense in criticising the original manuscript, though he was less involved in the field work than the others. He was the one of the three who always got things done in the laboratory, working on the records.

When one is getting to the stage in life where active participation in field work becomes difficult or impossible, it is good to have an assistant who can carry on independently. That I have in Gerry Kuhn, who is, as I mentioned earlier, studying coastal erosion in the San Diego area, a field in which I worked in the somewhat remote past. He is gathering together all of my old slides and old photographs, and getting them into a form that can be used readily to look for coastal changes. Furthermore, he is going way beyond anything that I did in the past, and I am delighted to have him with me. If he finds that some of my ideas were erroneous, that is fine. I shall be glad to correct my errors.

The most interesting and stimulating, and perhaps also the most controversial of my staff during a portion of American Petroleum Institute Project 51, was my good friend Andreé Rosefelder. I became well acquainted with Andre when he spent a year in the United States, mainly at Scripps Institution. He is a Frenchman from Algeria, and was quite successful in developing the petroleum industry in Algiers during the days of French ownership. He became interested in marine aspects of geology and visited us at Scripps partly to scuba dive with Bob Dill. His life was always exciting, and he seemed to go from one narrow escape to another.

During World War II he opposed the traitorous Peytain French government in Algiers; he was captured and condemned to a firing squad. Just before his execution the French got word that American troops were

rapidly advancing on Algiers and he was released. He fought the rest of the war with the free French.

Subsequently, after amassing a fortune in Algerian oil, he became disgusted with De Gaul's reversal of sides in the fight for Algerian separation, and he joined in the bitter-end fight of Frenchmen against de Gaul trying to hold on to Algeria. His life once more was in jeopardy. He escaped by having friends pack him in a large box and ship him to Italy. There he worked in a menial job for some time, and I learned of his fate through Bob Dill. I cabled him, offering him a job which I could offer with my A.P.I. funding. He came promptly and we gave him a position where he had a free hand to develop instruments for use in marine geology. He was bursting with ideas for new methods to obtain better bottom samples.

For a time it looked as though we had a genius on our staff and my reports contained enthusiastic accounts of many of his ideas. The problem was that there was too much pressure in situations like this to produce almost immediate results and, like most successful inventors, Andre required plenty of time and lots of support to establish these ideas. Some of my committee members from A.P.I., and even some of my colleagues at Scripps Institution wanted to know what could be shown for the funds being devoted to this project and a foreigner. Finally Andre decided there was too much opposition and that he should find another position. In the meantime he had acquired many new and important friends and had no trouble finding other opportunities. In fact, he is now doing very well with some ideas for mining the sea floor. We have continued to be good friends. As a matter of fact, he asked me to be his best man when he married an English girl a few years ago. I have mentioned only a few

of his rather extraordinary adventures here, but I can assure you that he has tales to tell that can make your hair stand on end, particularly about his fights with de Gaul^l. That he is now welcomed in France is one of the remarkable reversals that have typified French policy in recent years.

Thus you can see that I have derived a lot of pleasure, and some sadness, from my close friendships which I have generally maintained with the people I have employed. Of course, the fact that I never had large numbers of employees at once has made it much easier, but I often wonder why large employers do not make more of an attempt to become friends with those who work for them.

Some years ago my colleague Milton Bramlette told me about how his uncle, who had developed a large shoe manufacturing company (Nunn-Bush) had preserved friendly relations with his employees. He arranged it so that they share the profits and are therefore greatly interested in the success of the company. There never were any strikes, and the employees share in the planning of the business, and so feel an additional interest. Friendly relations exist throughout the enterprise. How much better it would be if this were the general practice of labor and management. Maybe then we could really compete with the Japanese and Germans.

CHAPTER XVIII:

HOW A HALF-CENTURY HAS CHANGED THE LIFE PATTERNS OF DEVELOPING
MARINE GEOLOGISTS AT SCRIPPS INSTITUTION OF OCEANOGRAPHY

It is rather surprising to compare the conditions under which research was conducted during the period when marine geology was in its beginning phases with conditions in 1980. There have been changes since the early days, some 60 years ago, when I first got started in this new science, and the conditions that now exist are the result. In the old days I made use of any boat or ship which might bring me some information about the character of the sea floor. The results were often exciting as related earlier, but I always felt like a beggar at a feast until finally, in 1938, I was able to operate a fairly sizable craft for my research.

Even then most equipment was quite primitive and all kinds of difficulties developed. Most of these have now been overcome. The echo sounding devices are greatly improved and it is no longer necessary to read a flashing light to tell depth; it is recorded on a tape. It is even possible to tell what the topography is like on either side of the ship through use of the wonderful new side scanners which operate in part from devices towed along near the bottom. Nowadays when a marine geologist goes out on an expedition he is accompanied by electronics experts who are trained to operate all sorts of geophysical apparatus. The geologist can move from one laboratory to another, alternately observing the records showing what is beneath the bottom, such as folds and faults which may not show at all at the surface, and the changes in gravity beneath the ship which provide information on the nature of rock masses that are well below the surface. The magnetometers give interesting indications of whether the lava flows coming from the mid-ocean ridges at a particular time and place were negative or positive. This enables him to fit the zone he is crossing

into the stage of opening of the ocean ridge, say for example that the flow was erupted in a negative phase millions of years ago.

Geochemists have also made great advances not only in the study of rock formations which make it possible to tell whether they are dredging rocks from different intruded stages in layers of the ocean crust, but even that the rocks come from the underlying mantle. We used to think we had to obtain any information about the mantle, under the rather thin ocean crust, by drilling through the crust. This project, called "Mohole", caused great interest among a group of outstanding scientists some two decades ago. I suppose, looking back, that it was fortunate that the budget became so expensive that the project was abandoned after several years of intense planning. Fortunate in that in the meantime the deep drilling operations of the Glomar Challenger in the various oceans had taught scientists so much about deep drilling that it appears the early attempt would have resulted in a failure and taught us very little about the overlying ocean crust. This same deep ocean drilling has revolutionized our ideas about the history of geology and tectonics. Much of the plate tectonics development mentioned previously has resulted from these studies.

Equally important is the discovery of layers in the oceans where the chemistry of the water differs greatly from layer to layer. This has suggested to geochemists that bodies of water like the Arctic Ocean have undergone great changes, alternating fresh water and salt water composition, so that when connected with the main oceans it had a tremendous effect on the world climate. This history can be ascertained through water columns around the Arctic in which remnants of the fresh water stages are shown in buried layers.

Another important development at Scripps Institution during the past two decades has come from our Coastal Studies Institute. Douglas Inman who once worked with me as a graduate student for a short time, has since built up a group well known around the world for their expertise in coastal studies. They have been called upon for consultation all over the world in helping to find solutions for coastal problems. Doug Inman is now in charge of our Hydraulics Laboratory; he gradually shifted his primary focus from marine geology to physical oceanography. I am glad to see that he is now working in close association with Gerry Kuhn, particularly through his associate, Scott Jenkins, and the Beach Erosion Board of the Army Corps of Engineers. Coastal problems require a combination of the two branches of science working in cooperation. Here at Scripps Institution we are especially well prepared to fit the two branches together to accomplish results in producing beach and cliff erosion studies; more so than anywhere else in the country at present.

As these geophysical and geochemical ideas have come together in the study of marine geology it is interesting to note what has happened to scientists in the new field. They have become much more technically trained for their scientific work which I suppose is largely a good thing, but it may also detract from their training as naturalists, so that they may perhaps fail to see features which they would surely have observed in the days before specialized technology. I feel we need naturalists to go out looking for the phenomena of nature as well as scientists who devote most of their time to laboratory calculations of what should or might have happened. Both are important.

The life style of our young scientists has certainly improved in most cases. At Scripps Institution, for example, a number of shacks were built

around the two or three buildings used for classes and office and laboratory work, and these were living quarters when I first came to Scripps in 1934 for a few months. I suppose that now the conditions would be considered as below poverty level, but most of the people seemed quite happy and had enough to eat; they kept moderately warm in the winters by huddling around stoves in the living rooms. I remember my young son took joy in poking holes into the numerous knots in the thin wooden walls. Many of the occupants did not have cars so that getting groceries could be a problem, but there was much cooperation between families. The director's house was somewhat of an improvement. It had a fireplace and several more bedrooms than the others, but no luxuries, and very likely only one bath. As time went on many of the older shacks were torn down and the better off of the faculty acquired houses in La Jolla. The other houses were winterproofed and generally improved.

Finally in 19⁵61, under Revelle's directorship, a group of 18 of us purchased at a very low cost a large tract of property just north of the campus, mostly along a canyon which later became known as Sumner Canyon after Professor Francis B. Sumner who was a leader in our development. We subdivided this into 40 lots and also acquired ownership of the canyon which we made into a ~~game and agricultural~~ preserve to help protect the wildlife which is quite abundant there still. The net result of this expansion, along with considerable increases in real salaries has made a great difference in the life style of the faculty of the Scripps Institution, as can well be imagined.

The Institution has also grown enormously. Some idea of this growth is indicated by the comparative photographs of the campus when I first arrived and the way it looks now. Unfortunately, growth is not all that

is needed for success, and the signs of normal deterioration can be seen, perhaps indicating that we've grown too large and prosperous. We lose the close contact we used to have with professors from other departments, and even our own. I think most of us old-timers look back fondly on the weekly meetings we had with the small group at which some member of the staff would give a short talk on what he and his group were doing, or maybe describe the results of his most recent expedition. This kept us all abreast of what was going on at the Institution. Now people are more isolated, despite frequent seminars.

On the other hand, I think most people would prefer to have present-day conditions. There is no doubt that the better facilities in laboratories and on ships, along with ample funds for most necessary travel expenses is of great benefit to staff and students in helping them to accomplish their work. The extensive reports that one sees is a clear indication that we are not going to sleep in the lap of our new luxuries. I think it might be appropriate to finish by pointing out that much of this growth of the Scripps Institution can be credited to Roger Revelle despite the relatively short period during which he was our associate director and then director.