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Organization of geophysical parties for foreign exploration

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ORGANIZATION OF GEOPHYSICAL PARTIES

FOR FOREIGN EXPLORATION

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I. INTRODUCTION

Special conditions encountered in much foreign work make it necessary to consider many factors which are not encountered in domestic programs of geophysical exploration for oil. Although extremely difficult working conditions are frequently met in domestic operations by company and contract crews, the large store of past experience, the availability of fresh supplies, replacement or new equipment, and the proximity of the helpful home office make their surmountal more or less a matter of routine. Contrariwise, foreign operations are frequently conducted under much more difficult conditions, supplies and equipment can be secured only after long and costly delays, and the distance and inaccessibility of the home (executive) office leave practically all decisions to the party executive. With the rapidly increasing amount of foreign geophysical operations and the world wide extension in recent years of this activity, it is felt that special consideration of some of the problems encountered in the organization and operation of field parties for foreign service is pertinent and timely.

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II. LOCATION

The rosters of the Society of Exploration Geophysicists and the American Association of Petroleum Geologists show members in the following foreign countries among others:

Afghanistan	Cyprus	Italy	Philippine Islands
Angola	Denmark	Japan	Poland
Arabia	Dominican Republic	Java	Roumania
Argentina	Ecuador	Kuwait	Scotland
Australia	Egypt	Madagascar	Sumatra
Austria	England	Mexico	Switzerland
Bahrein	France	Morocco	Syria
Belgium	Germany	Netherlands	Trinidad
Borneo	Guatemala	New Guinea	Turkey
Brazil	Holland	New Zealand	Uganda
Burma	Hungary	Nicaragua	Union of S. Africa
Canada	India	Palestine	U.S.S. Russia
Colombia	Iraq	Papua	Uruguay
Cuba	Iran (Persia)	Peru	Venezuela

While geophysical operations are not being conducted in all of these countries at present, the activity of American geologists engaged in preliminary exploration indicates the probability that geophysical work will eventually follow in the majority of them. Practically never is a geophysical program undertaken until at least reconnaissance, and usually fairly detailed, geological studies have been made. Obviously, there are large areas, such as the plains, llanos, selvas or pampas, where surface geology is handicapped by the absence of surface exposures and of outcrops in adjacent uplifted areas. When subsurface data are also lacking, geophysicists must start from scratch. However, practically without exception the executives of the producing company or group of promoters have more or less general information upon conditions in the area of prospective geophysical operations. Few regions are entirely uninhabited and information gathered in trade relations is available to supplement that furnished by their own advance geologists. The size of some concessions is amazing. For example, the Standard of California holdings in Arabia are larger than the state of California, or over 158,000 square miles.

It is obvious that in the countries listed above the widest possible range of physical conditions will be encountered. These may vary from sparsely settled localities in New Guinea where native labor is almost unavailable, to the densely populated areas of England, where the very density of the population hinders operations. While most of these countries (as well as many others unnamed) must be listed as prospective territory, the greatest activity is at present concentrated in the Spanish-American nations and the Near and Far East. Hence these are the areas to which primary consideration will be given in the discussion that follows regarding the planning of a geophysical program and the organization of the geophysical parties.

A. Availability of Concessions

Like the famous recipe which begins, "First, catch your rabbit", the availability of concessions and the political considerations attendant upon the assignment and exploitation of a concession are of first importance. While the political phases are primarily the business of the company executives, the various governmental policies inevitably affect the conduct of the geophysical program. In some instances, particularly in those nations with present very strong nationalistic tendencies, special conditions and restrictions seriously hamper or entirely prohibit foreign development or activities. In practically all cases conformity to certain governmental regulations is required, not only in the terms of the concession, but also in matters of work requirements, methods of procedure, and the share or knowledge which the native administration has in the conduct and results of the program. While as stated, these questions are customarily primarily handled by the executives of the companies' exploration department, close cooperation between them and those planning the actual geological and geophysical programs is essential for satisfactory results. A thorough knowledge and understanding in advance of special or unusual operating conditions or requirements may save long and expensive delays or even mean the difference between success and failure.

A favorite examination question of the late Dr. C. L. Dake, Professor of Geology at the Missouri School of Mines, was, "What should be the first step in starting work in a new area?" The expected answer was, "Find out everything possible about the area before starting actual work there." Not only were geological data included in this study, but all facts that might possibly be of value in the proposed work. Nowhere is this advice so pertinent as in a difficult foreign area where even a little information may save months of effort and needless duplication.

B. Climate and Living Conditions

With the present rather unimportant exception of Canada and the European Countries, most of the areas of primary interest are either tropical or semi-tropical. In the majority of cases, and particularly in the Spanish-Americas and the Near East where most of the activity is concentrated, living accommodations for the field personnel are not available. Hence the problem of housing and feeding a considerable number of men under tropical field conditions becomes of major importance. In most instances the actual details of the camp operations are handled by the exploration department of the producing or contracting company for which the work is being done. If not, these matters will require the full attention of at least one man under the supervision of the Party Chief. These problems are discussed more thoroughly under the heading, "Equipment and Supply Organization".

Climatic changes in the plains areas of Spanish-America tropics are primarily those due to, or closely associated with, variations in the amount of rainfall. In those countries in the vicinity of the Caribbean Sea the typical rainy season begins in May and ends about November. During this period torrential rains fall frequently. Climatic conditions vary widely in any country. In East Central Mexico, for example, the damp cold at nights in January and February calls for three or four blankets, while during April and May the writer has experienced daily temperatures of 120°F in the office tent, which was covered by a fly and shaded by trees. In the sun the heat was of course much higher. Climate in these tropics is largely influenced by the altitude - with its consequent effect upon the moisture carrying wind currents. In some unusually favorable areas, such as the present exceedingly important Eastern Venezuela llanos, in and adjacent to the State of Anzoategui, geophysical operations may usually be carried on with only slight hinderance from the seasonal rains. This is due to the well drained, sandy soil and the comparatively moderate amount of rainfall. However, conditions vary from year to year, and in such years as 1938 when the rains were unusually heavy, operations may be retarded to a mere fraction of their former speed.

Lying west of the Venezuelan short grass llanos are the tall grass llanos of the States of Apure and Barinas, (formerly Zamora). A heavy soil and torrential rains produced by the proximity of the Andes Mountains to the west produce entirely different operating conditions. Combined with these climatic changes is a scarcity of roads or trails passable by trucks that require a considerably altered technique. In the dry season trucks and cars carrying geophysical equipment can make their way cross-country, although the mortality in springs will be heavy. However, when the heavy rains begin in this area an automotive transported geophysical crew must hustle their equipment from the back country to escape being mired down for months. In many areas passable by trucks in the dry season mules become the only mode of transport when the rains begin. Later, they too may bog down and bulls or oxen will transport the small amount of native freight moving. Down towards the Colombian border immense areas stand one to several feet under water and only native canoes or bongos move over the inundated tall grass llanos country. In such extensive areas operations during the rainy season can be conducted only with marine equipment. Even then, strong and rapid fluctuations in water levels introduce complications.

Illustrative of the amazing lack of preparation into which even an experienced organization sometimes slips is the experience some years ago of a major company which suddenly decided to embark upon a strong program of geological exploration just east of the Venezuelan Andes. With no thought of the vagaries of a tropical climate a number of geologists and engineers were shipped down to start work. They arrived in June and found one of the worst rainy seasons in years. Consequently, for the next six months several high-priced men spent the time bogged down in little native towns waiting for workable conditions. Preliminary investigation or even consultation with any of the many available individuals engaged in trade or cattle buying in this area could have easily given the information on climatic conditions that would have saved this waste. Reference to an encyclopedia or a good publication on physical geography and climate would have given the necessary information. While such lapses are rare the lack of information by the home offices on climatic conditions in areas to which geophysical crews are to be sent is frequently amazing. Careful attention to this feature will pay large dividends.

Even in desert or semi-desert areas near the tropics such as Kuwait and Iran in southwestern Asia seasonal variations in the climate are a controlling factor in an exploratory campaign. For about six months of the year, or roughly from April to September, a hot wind blows. Even the wandering Bedouin and his herds migrate from the desert areas until more bearable weather is resumed. For unacclimated foreigners to attempt to work during this time would be worse than foolhardy. Much can be learned from observation of the natives' customs and habits, for while his standards of living, health and sanitation may be utterly primitive, the processes of evolution have taught him how to adapt himself to that particular environment.

Consideration of tropical climate leads naturally to that of insects. While at first thought it would seem that they could little affect a geophysical program, their effect on living conditions and the morale of the personnel is often most important. There are many individuals who seem constitutionally unable to stand the constant annoyance and irritation of the swarms of insect pests usually encountered in the moist tropics, and whose morale soon disintegrates under such conditions. Even the most phlegmatic dispositions acquire an extra edge under the constant attack. The Eastern Llanos of Venezuela, fairly well drained and usually swept by a breeze, are freer of insect pests than most tropics. The humid climate of portions of Mexico, western and west-central Venezuela, Colombia and similar countries produce an insect condition impossible of comprehension to those who have not worked there.

As a final example of possible working conditions, the production departments of companies operating in Iran, Arabia, Iraq, and Bahrein must have air-conditioned, specially constructed tropical houses and various recreation facilities to make life bearable for their employees. However, the geophysical and geological crews who preceded them and who spent months and years finding the oil lived in tents, usually had no refrigeration, and for recreation were confined to the usual evening poker game.

C. Health

Sickness or injury of a member of a geophysical crew in the States ordinarily means only the inconvenience of securing a replacement or perhaps doubling up of duties for a short time. Operations abroad are usually conducted with a minimum of American personnel and replacements are some thousands of miles, and more important, perhaps weeks or months away. While the airplane has cut down travel times greatly, the formalities required in many instances before work permits, passports and other immigration formalities are satisfied may require weeks or even months in some instances before a new man can join the crew. Lacking trained replacements on the ground, even the temporary loss of a man becomes a much more serious matter.

As an elementary principle it is obvious that any individual selected for foreign service should be in good physical condition. A thorough physical examination is essential. Typhoid shots and smallpox vaccinations are standard precautions. Troubles with the teeth and the stomach are encountered more frequently under tropical conditions in a field camp. This is presumably due to the changed living conditions, bad water, lack of milk and fresh vegetables, and frequently the monotonous and perhaps rather greasy diet prepared by the native or Chinese cooks. Individuals with a "touchy" appendix are merely inviting serious trouble, for in a remote area where communication with hospital facilities may be a matter of several days or even weeks, an appendicitis attack may easily be fatal, whereas under ordinary circumstances it would mean merely a routine operation. Those required to wear eye-glasses should always carry at least one extra pair, and also a copy of the prescription, which can usually be filled in some large city of the country.

The twin scourges of the tropics are malarial fever and dysentery. The first is mostly encountered in the humid tropics while the latter seems to be prevalent in all tropical areas, and particularly where cleanliness and sanitation are especially bad. As well known, malaria is transmitted by the female Anopheles mosquito, and the only preventative is to avoid being bitten by an active carrier. As the mosquito is most active at night an invariable rule should be to sleep under nets, or if in a permanent residence, in a very well screened room which is nightly sprayed with an insecticide as a matter of habit. The usual cure for malaria is quinine, taken either by mouth or in shots, and/or the newer drugs, plasmaquin(e) and atabrin(e). Some individuals are unable to take the latter two. Salvarsan or arsenic shots are also frequently used to build up the system. The writer, having gone from over 165 pounds to less than 125 pounds weight in a few months during a malarial siege can testify to the need of physical strengthening.

Dysentery is of two types, amoebic and fungus. It may be contracted in a variety of ways, but usually either from contact, even though very remote, with a carrier of the disease, or else from eating contaminated food. In many areas all fresh fruit and vegetables are potential sources of infection and require boiling or treatment with a disinfectant such as a dilute potassium permanganate solution. Treatment of the amoebic type usually requires injections of emetine, while the fungus type may be treated with a variety of medicines, usually bismuth compounds. Stoversall and Chlorodyne, British medicines developed for the use of their Indian Army, are much used. Mild cases of the fungus type may often be cured in the camp by medicines such as Chiniofon, but ordinarily dysentery required prompt medical treatment.

A variety of infections from insect bites and the like are frequent. Gusanos (worms) hatched from an egg laid in the human flesh by a large mosquito-like fly, must frequently be extracted by a doctor when located in the more vital portions of the body. Infected tick bites are common. The first rule of health in the tropics is sanitation and cleanliness. Obviously, at least one member in authority on a party, and preferably its chief, should have had previous experiences under similar conditions. Beyond the above mentioned few items there are literally dozens of precautions that should be taken that only experience can teach. Practical information the experienced leader may impart is apt to range all the way from the invariable habit of shaking out ones boots in the morning to dislodge scorpions, centipedes or snakes that may have taken refuge there during the night, to the judicious observation that most foreign contracts carry the provision that anyone contracting a venereal disease returns home at once at his own expense. Of course, England, Denmark and some of the Continental countries have living conditions similar or equal to our own, and in such cases only the ordinary care in preserving health is required.

D. Languages

It is obvious that the ability to speak the language of a country is a great asset, particularly for those in the more responsible positions on a party operating there. In countries where the language is particularly unfamiliar or difficult, such as Arabia, Iran or Kuwait, it is probable that most individuals will acquire only a limited or at best, moderate, command of the language in a one or two year stay. However, a particular effort to learn as much as possible even in such cases should be made, as communications and operations through an interpreter are never fully satisfactory.

The greater portion of the foreign geophysical exploration for oil is done in Spanish speaking countries and in such cases any person of ordinary intelligence should soon pick up a moderate knowledge of the language. It should be practically a requirement that in operations in the Spanish-Americas those in responsible positions should be able to handle the language fairly well. Language barriers between the director of the party and his native labor may be a large negative factor in satisfactory operations. It may be observed in passing that the lisping Castillian all too frequently taught in our American schools is not the Spanish spoken in the Spanish-Americas. Typical of the average American's knowledge of languages, and even the technical man who should know better, was that of the official who thought his correspondence to Brazil should be written in Spanish.

E. Transportation

Accustomed as is the usual American to the all-weather highways of the States, it is difficult for him to realize the primitive transportation conditions still existing in most foreign areas where geophysical work is conducted. Even the field man who has battled the swamps of the Mississippi Delta or the sand hills of West Texas and New Mexico will be disconcerted to find he may not even have the passable roads that always formerly existed somewhere in the general vicinity of his domestic projects.

Transportation problems are discussed further under the heading of "Equipment and Supply Organization". However, it may be observed that land operations fall naturally into one of three methods:

1. Automotive   2. Animal   3. Manual

Among the examples of each type that might be mentioned are: (1) Eastern Venezuela, Kuwait, Saudi Arabia and Iran (in part); (2) parts of Mexico, western and west central Venezuela, parts of Colombia; (3) parts of the Barco concession of Colombia and adjoining areas in Venezuela, parts of Sumatra, Borneo and New Guinea.

Water operations, outside of the foreign location, are apt to be rather similar to those in the United States, particularly the Mississippi Delta area.

Airplanes, particularly the amphibians, have reduced to hours the time formerly measured in days or weeks required to reach a prospective location in cases of emergencies. Once there, however, the actual operations must be conducted by one of these methods, and it often happens that the same method will have to be used to travel from the local headquarters to the scene of operations.

It has been frequently demonstrated that the only intelligent attack upon the transportation problem is to design the equipment for the specific location and conditions under which it will be used. To do this requires either preliminary reconnaissance personally, and/or close cooperation with some person acquainted with the actual problems of transportation to be encountered.

III. PRINCIPAL TYPES OF GEOPHYSICAL EXPLORATION

More and more it has become the practice for major companies to map their concessions first by air photos. The advantages of these maps are too well known to require much additional discussion or argument, although a few points are well worth repeating. In entirely new country, which is only partially mapped or geologized, it is almost safe to say that no matter what the cost of aerial maps may be, it will be more than saved by the more efficient planning of subsequent geophysical operations. Unless an entire blanket coverage is intended, the aerial maps are used to determine locations of surface structures or suggestions of structures which thus furnish a starting point of operations. In a large and comparatively unknown concession this localization of efforts may mean the difference between early successful results which will encourage the backers to further efforts, and abandonment of the program because random shots at such a big target failed to produce results in a short time. Moreover, the saving in the actual operations by planning them more efficiently from aerial maps is very great. Trails invisible on the ground can be spotted from air photos. The usual native guide is familiar only with his own locality and hence can not compete with this source of information. The advantages of air photos for purposes of physical surveys, property, cultural and topographic determinations are well-known and highly important.

Only the three more usual types of geophysical methods will be considered. This will be done briefly, as their application is largely a matter of individual company policies. They are:

1. Magnetic
2. Gravimetric
   a. Pendulums
   b. Torsion Balances
   c. Gravimeters
3. Seismic
   a. Refraction
   b. Reflection

The three usual geophysical methods are listed roughly in the order of the amount of detailed structural information obtained from each of them. This is of course practically identical with ordinary operations in the States. The magnetometer is a reconnaissance instrument, useful in determining the attitude of the basement. Its use has greatly declined although it still has its place in foreign exploratory programs as a rapid and inexpensive method where large and unknown areas must be covered in a minimum of time. It is readily transportable by any of the three land methods.

Of the gravimetric methods the gravimeter is now probably the most common, although some of the various types of small pendulums of French or German make are frequently used, particularly by some of the European companies. Torsion Balances are still used to some extent, although not as they were at the height of their popularity about 1930. Probably the number of Torsion Balances in use in foreign areas is considerably greater proportionately than it is in the States. This may possibly be due to their greater use by European companies. Ground coverage, accuracy, ease of operation, amount of surveying per observation and other factors greatly favor the Gravimeter. For best results mounting in a light truck or boat is preferable although it may be transported manually. Its shape and size do not readily lend itself to packing on animals.

Application of the refraction and reflection seismograph methods are very similar to those in the States. However, successful reflection shooting usually requires the use of a drilled shot hole. If one of the truck-mounted drills is unable to navigate, recourse must be had to one of the portable drills such as the Evinrude pumper. However, there are many areas, such as interior Mexico, where outcropping and near surface hard formations are too difficult for any light drill. In such instances recourse must be made to water holes and stream beds for shot points, and successful shooting may thus be limited to the refraction method. Seismograph instruments may be transported by any of the various methods. Material advances have been made within the last very few years in reducing the size of the amplifiers, recorder and detectors. The transportation of dynamite, particularly in refraction shooting where 1500 - 2000 pounds or more a day may be used, may become one of the largest problems in difficult areas far from the base of supplies.

IV. PERSONNEL

The speed and success of practically any foreign geophysical program, regardless of the type, is largely determined by the character and quality of the personnel. Indifferent, trouble-making, or mediocre men on domestic projects can be replaced when desired, but these same individuals on a foreign project have a powerful advantage in the knowledge of the fact that their replacement would be a very slow and costly process and that their summary discharge would in all probability mean an indefinite suspension of operations. For this reason the personnel of any foreign party should be selected with the utmost care. If a choice should have to be made between character and ability the choice should lie with the perhaps slightly less capable individual who has demonstrated his dependability rather than a possibly more brilliant specimen who quits when conditions become tough.

Many formalities must usually be observed to secure admittance of the American personnel. Besides the usual passport, birth certificate, and medical requirements many countries of nationalistic tendencies now have a wide variety of restrictions on foreign technicians. Usually it is necessary to show that the presence of any particular man is vital to the operation of the party.

If at all possible the party chief of any geophysical crew, whether magnetic, gravimetric, or seismic, should have had previous foreign experience. While it is advantageous if the former experience has been in the same country, the next best substitute is experience under similar conditions. Only one who has previously met at least some of the different problems encountered under these circumstances can comprehend them. Difficulties with an unfamiliar language, arguing, cajoling, bluffing or somehow persuading a frequently indifferent or slow customs' office to permit the passage of equipment and supplies, handling native labor, and looking after the health and well-being of party members are problems not encountered in routine domestic operations.

Geophysical programs, whether by contract or company crews, are usually conducted under the direction of the geological department of the producing company. It very frequently happens that the geologists, though entirely competent, are unfamiliar with the details and requirements of geophysical operations. Much friction between geological and geophysical departments, particularly in the case of non-company crews, can easily be aroused by a lack of cooperation or diplomacy. A studied policy on the part of the party chief of carefully and fully explaining the reasons for the various activities and requirements of the geophysical operations is of the utmost importance. While it would appear that the necessity of such a course is obvious, examples to the contrary are all too frequent.

As previously stated, geophysical crews working abroad customarily operate with a minimum of trained American personnel. The lesser positions are usually filled by natives or other men picked up on the ground. Hence it is imperative that in the case of key positions such as instrument operator and geophysicist some other members of the crew should be competent at least to carry on their duties in cases of an emergency until a replacement can be secured. In the case of seismograph crews a radio man is often capable of "Doubling in Brass" to the extent that he may replace the regular operator or shooter at will. The assistant geophysicist should also be capable of substituting for the geophysicist, and in practice should and does carry on the routine interpretation and computing, thus permitting the geophysicist to devote most of his time to program planning and general administration, although at all times keeping a close check upon the interpretation.

In domestic operations the positions of party chief and geophysicist are sometimes filled by different men. However, for foreign work it is the firm opinion of the writer than the functions of both must be handled by one individual for efficient operations. More or less routine details of field administration are quite properly delegated to the operator and of interpretation to the assistant geophysicist but the general authority should vest in one man. It is understood that the party chief has at least a working knowledge of the duties of each position on the party.

The operator should obviously be a man thoroughly familiar with his instruments, and should know not merely the routine operation of them but should be conversant with their principle. He should be able to reconstruct from spare parts apparatus damaged or partially destroyed in the inevitable mishaps attendant upon work under difficult conditions. His ability along this line may well mean averting a long and costly shutdown.

One of the most valuable men on any crew and one now generally included in all personnel selections is the mechanic. He should be not only a good shop man, capable of handling the tools in a machine shop, but more important, should be a real "handy man" and able to perform a required job with the limited facilities usually available. On parties using automotive or marine equipment the mechanic is of course indispensable in keeping the equipment in operation. However, even with animal or manual transportation, there is a definite need for a good handy man. Personal evidence of the value of such a mechanic was afforded the writer on a mule-transportation seismograph project. Using only a breast drill and simple tools carried in his field kit a small lathe was constructed and repairs were made to a battery charging motor which saved an expensive shutdown of two weeks.

Shooters on a seismograph party may possibly at times be developed from natives, or found among the wandering American miners or construction men encountered everywhere, who have had experience handling dynamite. However, the policy of using trained men is decidedly preferable as so much of the safety of operations depends upon the powder man. Also, the now general requirement that the shooter must be able to operate radio transmitting and receiving equipment at the shot point generally rules out the untrained man.

Surveyors may be an actual part of the geophysical crew or may merely be detailed to it by the production company for which the work is being done. The former procedure is usually preferable as surveying should come directly under the authority of the party chief for most satisfactory results. It frequently happens that surveyors may be found locally, either from the natives or from more or less itinerant American engineers who may be encountered almost anywhere. While these may be used to supplement the regular personnel the quality of work required demands the services of thoroughly reliable and competent surveyors. In the States with an established system of known boundaries and ties, a rather mediocre surveyor may perform the required duties satisfactorily enough. However, in the unsurveyed and sometimes unexplored areas covered in foreign operations a base system of coordinates and triangulation networks must usually be established upon which all subsequent locations are made. The astronomic and solar observations and the development of the grid system call for engineering information beyond that of the run-of-mine surveyor. The party chief should likewise possess at least a working knowledge of the engineering requirements. In passing, it may be observed that the engineer will probably have to be the hardest working man on the party.

The old adage stating the harmful effect of "One bad apple in the middle of a barrel of good apples", may be strongly exemplified by the presence of one trouble-making individual on a party. The strain of operations under difficult conditions and uncomfortable living accommodations, constant annoyance by insect pests, and worst of all, enforced periods of idleness because of unfavorable weather conditions, will develop sharp edges in ordinarily congenial dispositions. The presence under these conditions of one disgruntled man desirous of promoting trouble for the party management may be the leaven which changes an ordinarily cooperative crew into a bunch of discontented individuals and cliques. The trouble-maker may be in that frame of mine because of salary discontent, living or working conditions not as expected, or for any one of various reasons, the most frequent of which is plain jealousy of the superior position of the party management. While it may appear that excessive emphasis is placed upon this subject, the occurrence is so common and so serious that its importance can hardly be exaggerated. Except in serious cases, word of the friction rarely reaches the executive department back in the States, as the party manager is to a large measure forced to pass over and ignore unpleasantness in order to continue production. In ordinary circumstances in the States such a trouble-maker would be summarily discharged, but he knows, as well as the party manager, that the time and difficulty required for his replacement make that course practically impossible except as a last resort.

The question of the choice of personnel for a foreign party to operate under difficult conditions is a major executive problem. The character, demonstrated ability, and past record of the prospect are the major considerations. If he has weakened or quit under tough conditions before the chances are good for a repetition of the act. Frankness as to conditions to be encountered is essential, for nothing angers the entire personnel so quickly as to find living and working conditions not as represented. If told before starting the job that it will be difficult, that the camp will be remote, that weather and insects will be bad, and that recreation opportunities are practically non-existent, some prospects may refuse to go. Those who do accept, however, do so with an understanding of conditions and are much more apt to see the job through in a cooperative spirit.

Salaries for foreign operations are customarily substantially higher than for domestic work and usually include ordinary living expenses. However, the best attraction for the higher quality man is the promise of preferment in promotion upon his return to the States after the completion of the foreign project. It is needless to say that such promises must be strictly kept because of future relations, if for no other reason.

The question of whether married or single men are to be chosen is a most vexatious one. While the single men have fewer home ties and can travel at will, the majority of the older and more experienced men required in the key positions are usually married. Unless living accommodations for the wives are available in a nearby city or permanent camp, their presence on a foreign party living in a field camp is most generally not feasible.

Repeating previous statements, while only thoroughly competent men are sought for foreign assignments, the largest single qualification is the demonstrated character of the prospect. This is particularly true on the more difficult projects. Too many candidates for the positions are youngsters with ideas of romance, adventure, and travel. Actually, the romance is usually very dark, work and not adventure is the purpose of the job, and the travel portion is only incidental and eventually becomes tiresome if done on ones own legs or the back of a hard riding mule.

V. EQUIPMENT AND SUPPLY ORGANIZATION

A. General Considerations

The design of geophysical instruments is strictly a matter of company information. Hence, no attempt at its description is included except for broad statements of certain modifications in design for the purpose of adapting it to one of the three previously stated general classes of land transportation, i.e.

1. Automotive 2. Animal 3. Manual

Water transported projects abroad are much less numerous than those on land. Moreover, the marine equipment required for foreign operations is very similar to that now used so extensively in the Louisiana and Texas Gulf Coast. As boat and truck mounted instruments are normally readily interchangeable the same general remarks apply to each type.

The basic principle of equipment specifications for most foreign service is the fact that it will probably undergo very hard usage under unusually difficult conditions. Hence it should be as sturdy and simple as possible, and with all parts readily exchangeable and easily replaced when the inevitable deterioration or accident occurs. Closely paralleling this feature is the requirement that a complete stock of replacement parts and supplies adequate to meet practically any emergency should accompany the original equipment.

It is obvious that the climate of the prospective territory is a major factor in the design of all equipment. The very humid conditions encountered in most of the Spanish-Americas requires the use of special moisture-resisting seals wherever possible. Transformers, condensers, vibrators and many other parts quickly fail if not protected. In dry, dusty areas such as many of the near Eastern countries provision must be made as far as possible against the infiltration of fine dust particles which will penetrate the most minute openings. In all tropical countries photographic supplies should be tropical-packed. Recording paper or film is packed in sealed foil containers which exclude air and dampness, and even the temperatures of 120° - 140°F frequently encountered have no immediate effects. Deterioration under these temperatures is somewhat more rapid, however.

The necessary tools for making any required repairs should of course be included. In a few instances shop facilities may be available near the scene of operations, but generally the whole range of repair work must be accomplished by the equipment at hand and the initiative of the party members. Selection of the tools should be done by the party mechanic and some individual familiar with conditions in the prospective country. In some instances it may even be possible or preferable to purchase tools and certain supplies in the larger cities of the prospective country. While an unduly burdensome amount of tools and repair parts should be avoided the supply should be adequate for any possible contingency. One single day's shutdown of operations may represent the loss of a greater sum than the cost of an entire stock of tools.

The entry of equipment and supplies into a foreign country is often a slow and difficult process. Under all circumstances it is a task requiring a thorough knowledge of the customs' formalities and regulations. Ownership papers, as well as complete, detailed descriptions and specifications of all material are essential. In most ports of entry the services of Customs Brokers or Agents are practically essential for material accompanying the party, and particularly for subsequent shipments. These firms, which specialize in expediting the passage of goods through the customs in each direction have the information, experience and contacts required to secure reasonably prompt service. Export as well as import regulations add complications in most foreign countries. The mañana spirit which apparently guides the actions of many officials in that service in some countries may leave badly needed supplies lying untouched in the customs' warehouses for months unless convoyed through the maze of regulations by the brokers.

B. Automotive Transported Equipment

The majority of foreign geophysical operations are conducted by the use of automotive equipment. Roads are usually few, trails are scarce, and most of the work is done cross-country, yet the American-made cars and trucks stand up under the excessive punishment surprisingly well. An excellent object lesson in the requirement of sturdy transportation units was recently afforded by a certain European electrical party which came to Eastern

Venezuela to conduct some experimental surveys in the same area over which American seismograph parties have been operating for several years. With their equipment carried by light European cars and trucks, only about two months of the rough, jolting usage were required to put their transportation units completely out of commission.

The usual makes of cars and trucks used are Fords, Chevrolets and Plymouths, with some Internationals and an increasing number of Marmon-Herrington converted Ford 4-wheel drive units. Fords have apparently given the best performances as the great majority are of that make. Magnetic and gravimetric surveys are usually conducted with lighter trucks or pickups. Hence the discussion of seismograph transportation units also covers their use for the other two types of exploration.

Seismograph operations usually require the use of drilled shot holes. A few American manufacturers have developed the truck-transported drill to a state of perfection unapproached, and practically unattempted, by foreign truck makers. While shot hole and core drills are produced by other manufacturers the great majority are produced by the George E. Failing Company, of Enid, Oklahoma and the Sullivan Machinery Company, of Michigan City, Indiana. Their units are customarily mounted on Ford trucks, though some Marmon-Herrington 4-wheel drive Fords and FWDs are also used.

Brief specifications condensed from the Sullivan catalogues of their three drills usually used for shot hole or core drilling are enumerated herewith:

1. Model No. 36 Drill

The complete unit consists of a rotary drill with built-in hoisting drum, 3" x 30" twin hydraulic feed cylinders, two speed transmission, FM 3 1/2" x 4" slush pump, folding 17 1/2' single sheave steel mast with hydraulic lift, closed oil system with positive displacement, rotary oil pump - all mounted on a bolted and welded structural steel frame for factory or field mounting on a short wheel base 1 1/2 ton truck. Power is supplied by the truck engine and power take-off with separate clutches for the drill unit and the circulating pump. Feed can be quickly converted from hydraulic to kelly by inserting kelly bushings in place of chuck jams. Capacity is 800' of 2" core, or 350' of hole for 4 3/4" casing. Weight mounted is 6800 pounds.

2. Model No. 37 Drill

This is a heavier version of the No. 36 Model. The principal changes are: A 25' double sheave mast, the usual use of a separate power unit drive for the drill proper, hydraulic pump for hydraulic feed, mud pump F x F 4" x 5", three speed transmission rotary table. Capacity is 1200' of 2" core, or 850' of hole for 4 3/4" casing. Weight mounted is 11,000 pounds.

3. Model No. 41 Drill

This is a heavy duty rig which includes multiple speed reversible rotary table equipped with hydraulic feed and automatic check, mud pump F x G 4 1/2" x 6", power drive from single or dual engines. Twin hydraulic cylinders of the hydraulic feed are 4" x 36". Capacity is 2000' of 2" core, or 1200' of hole for 4 3/4" casing. Weight mounted is 21,000 pounds.

An even heavier portable Model, No. 51, with a capacity of 3500' of 2" core or 2000' of hole for 4 3/4" casing is also produced for deep core and structure drilling. Its weight is 37,500 pounds.

For use under very difficult surface conditions the various drill manufacturers arrange fittings for mounting on crawler tractors. With the use of caterpillar units any area can be traversed in which swamp or water conditions are not too difficult, or where the time and labor required to open trails through wooded or jungle country are not excessive.

The amount of footage that can be drilled under favorable conditions with a truck transported shot hole drill is truly amazing. Six to eight holes 60 to 70 feet deep are regularly drilled in an eight-hour tour, including the required moves and time for digging slush pits. One driller, his assistant and/or water truck driver customarily constitute the crew. A water truck equipped with a casing pulling device, usually a mast arrangement, customarily accompanies the drill unit. An extra truck or pickup is also sometimes used. All trucks are equipped with winches of various designs. Very heavy duty tires, usually duals, but sometimes triples or extra large singles, are used. Mud tread tires are customary.

It is of interest to observe that in some desert or semi-desert countries shot holes in many cases have been later utilized as water wells by the native populace.

Seismograph instruments are customarily transported in specially revamped 1 1/2 ton panel body trucks, although some few organizations use a form of trailer. Heavy duty tires, either duals or over-size singles with mud treads, are used. Puncture-proof tubes are essential in thorny, rough, or stony areas. Winches are a necessity, preferably those driven by a power take off. Wire or cable trucks, if used, are usually one-half or one-ton capacity. Miscellaneous trucks, pickups, station wagons, and sedans are used for the surveyors, party chief and other members of the crew. In difficult areas winches are necessary.

C. Animal Transported Equipment

Geophysical equipment is frequently transported by animal power in difficult areas. Carts or wagons may be used if the country is fairly open or if passable trails already exist, or can be cut without too much difficulty. Horses, mules, burros or oxen may be used to pull them. In a tropical environment, mules withstand climatic conditions and poor forage better than horses and are much faster than oxen. Moderately open and developed areas such as Trinidad, Cuba and the West-Central Venezuelan Llanos are typical areas in which mule carts are customarily used for transporting geophysical instruments, supplies and camp equipment.

The design of geophysical instruments to be transported in carts ordinarily is little different from conventional truck-carried apparatus. Provisions to absorb the jolting due to the rough terrain usually traversed and the lack of springs in the carts is the main consideration. Small portable drills, both the usual rotary type for ordinary digging and cable tools for hard rocks, are made in sizes transportable in carts. They may be readily disassembled into parts of a size that can be handled without too much difficulty. Using 1" drill rods and a 3" to 4" fishtail bit they can produce 100 foot holes in reasonable time under ordinary drilling conditions. The Evinrude Pumper is one type of a quite light, portable drill. Lack of weight is of course the chief difficulty in drilling hard or tough rocks.

Special provisions for developing seismograph records must be made when the conventional truck dark room is not available. The usual equipment consists of a case in which are fitted four covered cans containing the developer, fixer and two wash waters. This case is covered by a dark bag fitted with arm holes. All processes are done by feel, supplemented by timing. Under average field conditions where no temperature control is possible this requires quite a knack. However, it is one routine operation for which an intelligent native can usually be trained.

There are many prospective areas where topography, terrain conditions, and vegetation are too difficult for the use of animal drawn wheeled vehicles, but where they are not so extreme as to require porters. In such cases, which are encountered particularly in many of the Spanish-American countries, operations are conducted with surprising speed and efficiency by the use of animal packed equipment. Although horses or burros are sometimes used, mules are ordinarily employed, for as previously stated, mules withstand difficult conditions better than horses. While burros have great resistance, due to their short legs they mire in the mud more easily than mules and are more apt to lose their footing while crossing rivers. Their load capacity is also less.

A few fundamental principles govern the design of any equipment to be transported by pack mules (or other animals). The total load per animal should usually not exceed 200 pounds. This total must ordinarily be evenly divided into equal loads on each side. Moreover, each of these should be of such a size and shape as will be best carried by the animal, and also be susceptible to quick and convenient packing and unpacking. It is with difficulty that one single, heavy load can be satisfactorily packed on one animal. The container cases must be adapted to the customs of the native animal handlers in the prospective country, for while it may appear far fetched to design geophysical equipment to a size acceptable to some unknown, remote and obscure "mule-skinner" some thousands of miles away, the hard fact nevertheless remains that eventually native mule packers will have to be depended on to transport safely valuable and delicate instruments. In Mexico, for example, aparejos or pack-saddles are ordinarily not used, instead two thick pads laid across the animal's back receive the loads. These are fastened by separate cinches and ride high up on the animal's sides. The carrying cases are thus tilted at an angle of about 30° from the vertical. This seemingly unimportant factor means that all equipment inside the carrying case must fit very tightly and must not be injured by the tilting. Further, the pack boxes riding on these pads have a very definite optimum size, which is determined by the size of the animal. Pack boxes about 10" wide, 18" deep and 24" long have been determined by experience as being the most suitable size. This is approximately of the same dimensions as the ever-present gasoline or kerosene packing case holding two 5-gallon tins which is found everywhere, and which is much utilized by the natives. Thus by a seemingly round about and remote chain of circumstances there is determined the size and shape of a container which in turn places the maximum limits of size, shape, and weight that must be observed by the designer of geophysical apparatus. Articles that do not have to be packed in containers of course may exceed those pack box dimensions, as for example, tents, cots, etc.

Any attempt at an adequate discussion of the many problems involved in the design of equipment for an animal packed party is far beyond the scope of this discussion. That the instruments must be unusually sturdy and capable of withstanding severe and ordinarily unexpected shocks and treatment is an unescapable fact. Some time or other during the course of an ordinary job it is a practical certainty that each and every piece of equipment will be bucked off of an obstreperous pack mule, dropped by a packer, and/or submerged while fording a river. Added to these are ordinary occurrences such as bumping packs against trees and rocks along trails, wetting by sudden rains when the pack covers are not in place, and many other hazards that a geophysicist doing only routine work with truck equipment in the States can scarcely comprehend.

Drilling equipment transportable by pack mules represents a further reduction in size and weight from cart or wagon equipment. Portable, knockdown, motor driven drilling equipment capable of 100 foot holes under ordinary conditions is available. The mud pump and engine usually constitute the heaviest and most awkward pieces.

Transportation of camp equipment and living accommodations for the American and technical personnel, as well as that for the native labor, also represents a very large problem. This may either be supervised directly by the party chief through his native foreman, or in conjunction with men from the geological staff who are apt to be accompanying the party. For example, consider a seismograph party that may be operating in one of the Spanish-Americas, as Mexico. It will comprise about a half dozen members of the geophysical party proper, two or three engineers and geologists, a permit man familiar with both the ordinary natives and the various Indian groups, and anywhere from 20 to 50 permanent native laborers. Additional trail cutters, etc., may be picked up locally as the work progresses from one Indian village sphere to another. Even with each American's personal effects limited to half of one standard size pack box, a cot and bedding, (no folding chairs, etc.) a very large number of pack mules is required to transport the bare essentials of apparatus and living accommodations. Counting saddle mules and those required for a four or five day pack of dynamite from the end of truck transport, a total of 100 to 150 mules will be kept busy at all times. Supplying food and pasture for this many animals is in many locations an exceedingly difficult task.

D. Manually Transported Equipment

As working conditions become successively too difficult for ordinary trucks, 4-wheel drive trucks, animal drawn carts and wagons, and finally for pack animals, the last recourse for transportation becomes man himself. The design of geophysical instruments that can be packed by porters is not very different from those that are to be packed by mules. If the topography and terrain are not too extremely difficult a good, well fed porter can carry about 80 pounds. While a pack mule can carry 200 pounds, it must usually be distributed in two packs, one on either side. While bulky, heavy articles such as tents may be carried much easier in one piece by pack animals, it is evident that in case of necessity porters can transport the material for a geophysical program under any conditions where a man can walk or wade.

Areas in which porters rather than pack animals must ordinarily be employed are fortunately limited. Parts of the Spanish-Americas such as sections of the Barco area of Colombia, and parts of Borneo, Sumatra and New Guinea constitute the principal locations where geophysical work using this method is now being actively pursued. The usual reason, and particularly so in the Netherlands East Indies, why porters rather than animals must be used is that the very thick jungle, bad swamps and standing water can be traversed only by men. In such areas, the number of combined porters and brush cutters may reach 200 to 400 men for a gravity party. For a seismic party, and particularly if much dynamite must be used, that number would be materially increased. Even so, only the barest necessities for shelter and food would be carried for the party, American and native alike.

Manually portable drills for shot hole drilling have been developed and are in use both abroad in some of the very difficult areas of the United States, as the Mississippi Delta. These drills and battery charging equipment usually represent the heaviest and most bulky apparatus that cannot be conveniently disassembled further.

VI. SUMMARY

The world-wide search for petroleum has created a demand for American personnel and equipment for geophysical operations abroad under different, and frequently much more difficult conditions than those to which they are accustomed in more or less routine work in the United States. A very brief consideration of some of the unusual factors involved has been the purpose of this paper.

Passing over marine work, where operating conditions are generally similar to those in the United States, special problems encountered in each of the following types of transportation were considered: (1) Automotive; (2) Animal; (3) Manual.

Personal experience, or close contact with someone having a practical knowledge of actual conditions to be encountered, is of the utmost necessity in the practical design of the equipment. Ruggedness, lightness, compactness and durability in the instruments (particularly for animal and manual transportation), must be emphasized to a greater extent than in domestic operations. Availability of replacements is vital when an unexpected requirement might cause a prolonged and very expensive delay while the part is being secured.

Important as are the specially designed instruments for difficult foreign work, they are less vital to the success of such a program than the quality of the personnel conducting the work. (These statements are meant to apply only to the difficult areas, for geophysical work is also being conducted in foreign countries where an unfamiliar language is practically the only hardship.) Living under the difficult conditions often encountered, particularly when the equipment must be packed by animals or men, calls for qualities in the personnol not possessed by many individuals. It is for this reason that the selection of the personnel for difficult foreign projects is the most important part of the executives' duties. Although instruments may be designed to meet these special requirements, the most important factor in the success of the party will be the capabilities and the intestinal fortitude of the men who operate them for many months under strange and difficult conditions.

BIBLIOGRAPHY

The sources of the material contained in this thesis are primarily the writer's own personal experiences and observations. These are supplemented to some extent by personal communications and data from various companies' activities which may not be quoted directly. As this thesis is not based on information taken from texts or other articles, there is no need for a bibliography.

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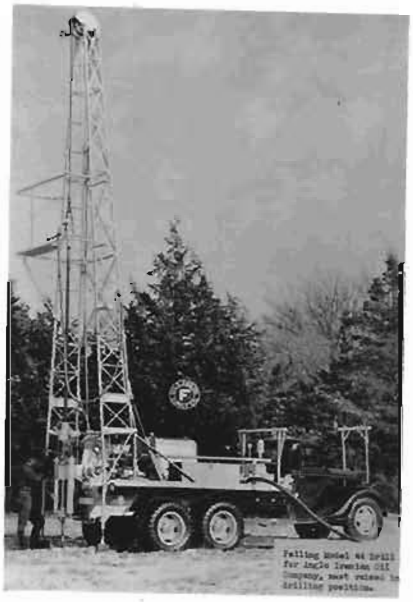

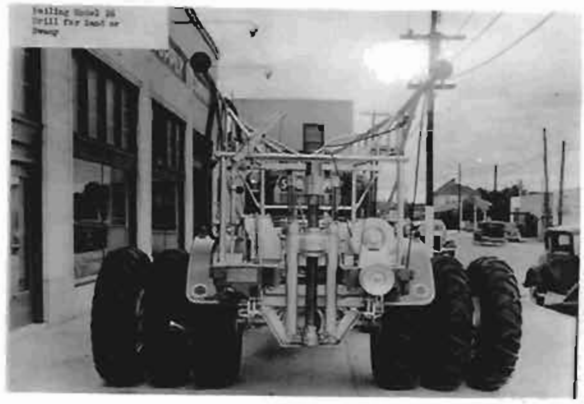

Failing Model 36 Drill
for Sand or Swamp

Failing Model 44
Shot-Hole Drill

Failing Caterpillar -
Mounted Drill

Failing Model 45
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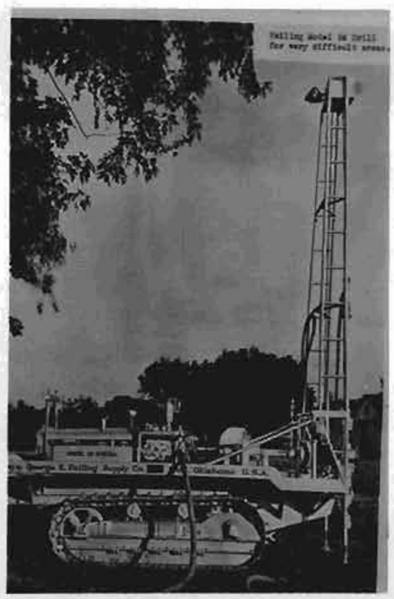
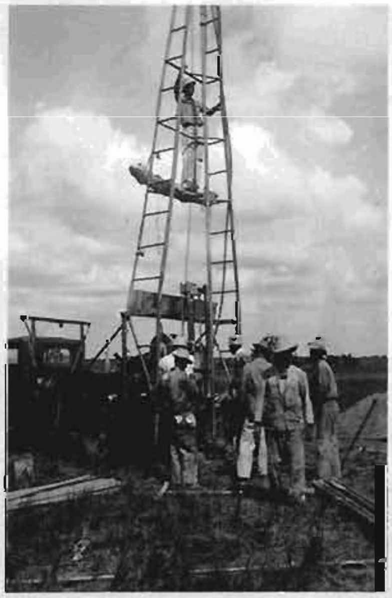


Seismograph Pack Train
Fording a River.
Spanish-America

Seismograph Pack Train
Spanish-America

Seismograph Shot-Hole
Drill - Venezuela

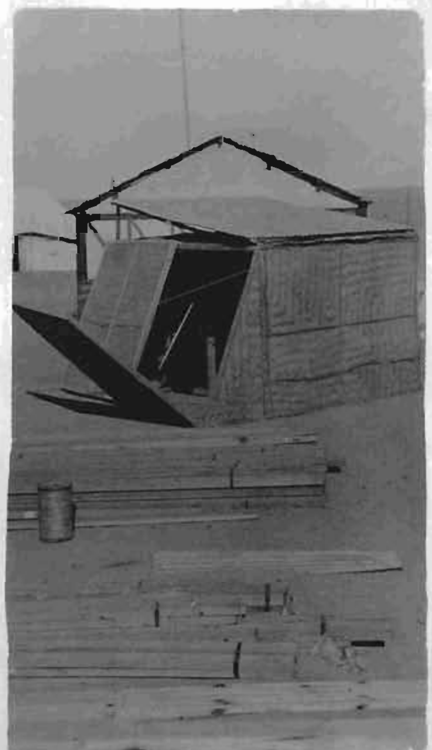
Typical Jungle Country
Spanish-America



A Combined Geophysical
Party Ready to Leave
for the Near East

Seismograph Shot-Hole
Drill - Venezuela

Sun Printing Frame in
a Geophysical Camp in
the Near East



Typical Seismograph
Instrument Truck

Geophysical Camp.
The Near East.

Seismograph Operations
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Failing Model 44
Drill and Water Truck

Typical Eastern Venezuela
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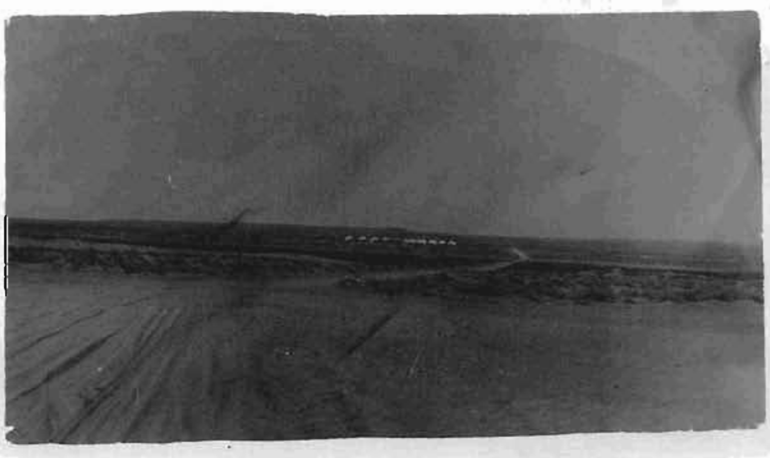

Typical Kuwait
Desert Topography

Camp - Colombia

Seismograph Camp
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Airplane Connections.
Eastern Venezuela Seismograph Camp.

Seismograph Field Camp.
Spanish-America

Native Labor Camp.
Venezuela - Note Hammocks
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Typical Seismograph Setup.
Mule-pack Instruments.
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Seismograph Houseboat and Launches. Colombia and Ven.

Seismograph Supply Bongo Venezuela - Colombia

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Native Labor - Colombia

Suddenly Flooding Rivers
are Hazardous - Mexico

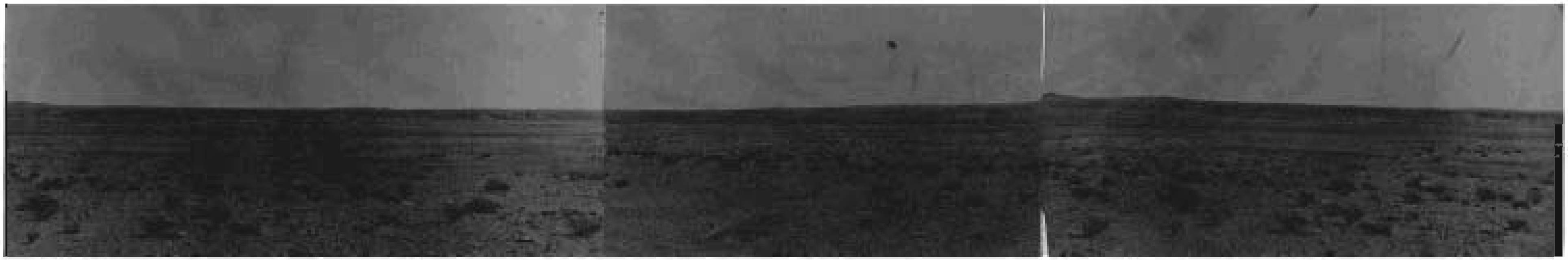
Swimming Saddle Mules
Across a River.
Spanish-America.

500-lb Refraction
Shot in Mud Hole.
Spanish America.

Assembling Mule Pack
Seismograph Equipment.
Spanish America.

500 lb Refraction
Shot in River.
Spanish America.

American Seismograph
Camp. Note Mosquito
Nets. Spanish America.



Kuwait

Moving Mule-packed Camp.
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Jungle Along Eastern
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