EVALUATION

Course Code: ESM 422

Course Title: RESOURCE EVALUATION

Course Developer: Dr. Uwem J. Ituen
Department of Geography and Regional Planning,
University of Uyo, Uyo, Akwa Ibom State
E-mail: uwem_ituen@yahoo.com
Tel: 08037810411

Course Writer: Dr. Uwem J. Ituen
Department of Geography and Regional Planning,
University of Uyo, Uyo, Akwa Ibom State

E OF CONTENTS

MODULE 1 [INTRODUCTION TO RESOURCES EVALUATION]

MODULE 2 [TYPES OF RESOURCES EVALUATION]

MODULE 3 [METHODS OF RESOURCES EVALUATION]

Unit 1 Meaning and Classification

Unit 2 Physical Methods of Resource Evaluation

Unit 3 Economic Methods of Resource Evaluation/Analysis

MODULE 4 [GEOMORPHOLOGICAL TECHNIQUES]

Unit 1 Introduction and Overview

Unit 2 Geomorphometry

Unit 3 Seismic Techniques

Unit 4 Electrical and Electromagnetic Methods

Unit 5 Solid Mechanics

Unit 6 Fluid dynamics

Unit 7 Landscape evolution modeling

Unit 1 Meaning and Classification

1.0 Introduction

In this unit, the meaning of resource evaluation shall be considered. This is aimed at giving the students wider understanding of what resource evaluation really is. Also, the methods of resource evaluation which can be broadly divided into two approaches namely, the physical approaches and the economic methods. Issues surrounding these are discussed in this unit.

2.0 Objectives

a. To get the students to understand the meaning and subject matter of resource evaluation

b. To get students to know the basis for the classification of the resource evaluation methods into the two approaches mentioned earlier.

3.0 Main Body

3.1 The Meaning of Resource Evaluation

According to Wikipedia Resource evaluation is carried out to in order to quantify the grade and tonnage of a mineral occurrence. The aim here is to achieve by drilling to sample the prospective horizon, or strata where the minerals of interest are deposited. The ultimate goal of resource evaluation is to generate a density of drilling enough to meet the economic and statutory standards. Depending on the financial situation and size of the deposit and the structure of the company, the nerate this resource and stage at which extraction can commence varies; for small partnerships and private non-corporate enterprises a very low level of detail is required whereas for corporations which require debt equity (loans) to build capital intensive extraction infrastructure, the rigor necessary in resource estimation is far greater (Wikipedia, URL).

Resource evaluation also involves Resource estimation which may require pattern drilling on a set grid, and in the case of sulfide minerals, will usually call for some geophysical techniques like down-hole probing of drillholes, to delineate ore body continuity within the ground.

Irrespective of the method used, the aim of resource evaluation is to expand the known size of the deposit and mineralisation. The method discussed above pertains to the evaluation of mineral resources. However, when other forms of resources and assets are involved, some other methods may be used. It therefore makes sense to include economic methods of resource evaluation in this discussion.

According to Braband, Geier and Köpke (2003) an assessment of the (natural) resource base is fundamental to any development planning and project formulation effort. This provides baseline information that will help in formulating a strategy and identifying projects. It equally helps in ensuring the sustainability of the planned projects. Moving from the physical to economic/financial evaluation, in resources/assets, require applying appropriate and consistent values to each type of resource/asset. According to Domingo and Lopez-Dee (2007), this allows aggregation of different types of environmental assets, integration in wider sets of accounts and comparison with non-environmental assets in terms of their contributions to the wealth of a country. According to the work, in the System of National Accounts (SNA), assets are valued at market prices which often are not available for environmental assets since these are rarely traded in the market. In the absence of market prices, the best available method of valuation is resorted to as proxy to market value.

4.0 Summarycv

In this unit, the meaning of resource evaluation was discussed

5.0 Conclusion

6.0 References/Further Reading

Braband, D., Geier, U. and Köpke, U. (2003): Bio-resource evaluation within agri-environmental assessment tools in different European countries. *Agriculture, Ecosystems and Environment 98* (2003) 423ï 434

Wikipedia, the free encyclopedia: http://en.wikipedia.org/wiki/Mineral_exploration

Lopez-Dee (2007): Valuation Methods of Mineral Resources. 11th Meeting of the London Group on Environmental Accounting, Johannesburg, 26-30 March 2007.

M. del Mar Rubio Varas, 2005. "Value and Depreciation of Mineral Resources Over the Very Long Run: An Empirical

Contrast of Different Methods," Economics Working Papers 867, Department of Economics and Business, Universitat Pompeu

Fabra. Found at: http://www.econ.upf.edu/docs/papers/downloads/867.pdf. Accessed date: February 22, 2007.

ce Evaluation

1.0 Introduction

2.0 Objectives

To introduce the subject matter of aerial photography to the students

To get students to understand the history of aerial photography

To expose students to the geometry of aerial photograph

To get the students to know how to map from aerial photograph

3.0 Main Body

4.0 Summary

5.0 Conclusion

6.0 References/Further Reading

urce Evaluation/Analysis

1.0 Introduction

2.0 Objectives

a. To introduce the subject matter of the methods of resource evaluation to the students.

b. To get students to understand the different methods of resource evaluation

c. To expose students to the advantages and disadvantages of each method of resource evaluation.

d. To get the students to know how to carry out resource evaluation.

3.0 Main Body

3.1. **The Market Price Approach**

This has to do with applying the prevailing market prices where stocks of environmental assets are tradable in the market. Such must be observed in the market by the quantity of assets/goods produced or placed in stock. Examples of such minerals include petroleum, gold, copper etc. According to Domingo and Lopez-Dee (2007), only the produced mineral resources and proven mineral reserves can be valued at

direct market prices. Domingo and Lopez-Dee (2007), also stressed that there are four advantages in using the Market Price Method, namely:

ts an individual's willingness to pay for costs and benefits of goods that are bought and sold in markets, such as timber, mineral or fuel wood. Thus, peopleôs values are likely to be well defined.

b. Price, quantity and cost data are relatively easy to obtain for established markets.

c. The method uses observed data of actual consumer preferences.

d. The method uses standard, accepted economic techniques.

Limitations (After Domingo and Lopez-Dee, 2007),

a. Market data is available only for a limited number of goods and services provided by the resource and do not reflect the value of all benefits/uses of the resource.

b. The true economic value of goods or services may not be fully reflected in market transactions, due to market imperfections and/or policy failures.

c. Seasonal variations and other effects on price must be considered.

d. Usually, the market price method does not deduct the market value of other resources that are used to bring ecosystem products to market, and thus may overstate benefits

3.2. The Income Approach (After Domingo and Lopez-Dee, 2007),

The income approach is used as a proxy measure of market value or an indirect way of using market values, where these are not present. There are five (5) methods available and tried which take into account future benefits/income streams that can be derived from the mineral assets as provider of capital services. These are:

Net Price Method

n alternative to Net Present Value (NPV) is based on the Hotelling rent model which assumes that, as the resource becomes scare and under certain market conditions, non-renewable resource rent will rise at a rate equal to the rate of discount (interest rate). The value of the resource stock can be calculated simply as the current rent per unit of resource multiplied by the size of the stock. Since rent rises over time at a rate exactly sufficient to offset the discount rate, there is no need to discount future resource income. This method is easy to apply, but is found to overestimate the market value of the valued resource/assets.Some countries of the world apply this method in some of their resource evaluations. Example includes The Philippines which made use of the net price method in its initial mineral accounts series and was

exploring movement to net present value method. While Canada applied both the NPV method and the net price method (Domingo and Lopez-Dee, 2007).

Limitations

a. The assumption of the Hotelling model that under perfect competition, the rents would rise in line with the rate of interest may not hold in reality due to market imperfection.

b. The rent used may include other forms of rent, e.g. rent due to the differences in the cost of production, monopoly rents due to the exercise of market power in setting price, in addition to the true resource rent.

c. The world prices of minerals are not governed by perfect competition.

El Serafy Method or User Cost Method

ntal resources/assets that generate marketed services. It makes a distinction between the ñtrue incomeò and the ñgross receiptsò generated by an asset.It defines true income as the amount of income that would be sustained indefinitely regardless of the actual finite lifetime of the asset by suitably investing a portion of the gross receipts generated which can be the depletion cost, otherwise referred to as the user cost. In terms of formula, the relationship between true income and gross receipts is: $N - X = N/(1+i)\ n + 1$ where X is the true income that can be consumed, N is the total annual receipts (net of extraction cost), i the rate of discount and n the further number of years for which current extraction rates could be sustained.

In order to apply the user costs method, many assumptions are required that are likely to bias the estimates. Regarding Nt, the current level of receipts is held constant during the lifetime of the resource. The rate of extraction is also assumed constant until the final exhaustion

of the resource, thus the life expectancy of the reserve in the present year, n, is not allowed to

change over time. It also assumes a constant discount rate.

Net Present Value (NPV)

The NPV for valuing mineral resource stocks

and changes in stocks has been recommended by the System of National Account (SNA) as well as other environmental accounting agencies. The study conducted by Domingo oil resource/assets group indicates that almost all the countries surveyed adopted the NPV method except for the Philippines. The NPV is a standard method that predicts the net income flows of an asset over its entire economic life. It entails forecasting the stream of future net revenues a mineral resource would generate if exploited optimally, and then discounting this revenue stream using an appropriate cost of capital. Under certain conditions -such as no taxes ï the sum of the discounted revenue values from each time period will equal the market value of the resource.

Advantages.

NPV has four key elements to evaluate an asset/investment:

Time Value of Money. NPV recognizes the concept that a dollar earned today is worth more than a dollar earned five years from now.

Income Flows. NPV calculates a resourceôs expected income flows and includes the unique risks of these. Using NPV helps to eliminate accounting inconsistencies, since the income flows encompasses all the benefits not just the profits.

Risks. NPV incorporates the risks associated with a resource via the expected income flows and/or discount rate.

Flexibility. NPV provides flexibility and depth, since the NPV equation can adjust for inflation and be used with other analytical tools such as Scenario analysis.

NPV is consistent with maximizing the value of a firm and is used by investors in the evaluation of a company or in capital budgeting decisions when comparing the value of y benefits, however, NPV has some limitations of which valuators need to be aware of.

a.Income Flows and Discount Rate

An NPV analysis has two main inputs: income flow and cost of capital. Income f\low represents the forecasted Net Benefits during the lifetime of the resource. In most real-life situations, determining this is not easy, considering the number of assumptions and expectations underlying the actual income flow. Choosing an appropriate discount rate is crucial to the NPV calculation. There are several ways to approximate the discount rate but the most common is to look for an investment of equivalent risk whose discount rate is known. A basic approach in selecting an appropriate discount rate, is to consider the rate of return which the capital needed for the project can yield if invested in an alternative venture. Obviously, NPV value obtained using variable discount rates within the lifetime of the resource is more realistic than that calculated using constant discount rate for the entire life of the resource.

For some professional investors, their investment funds are committed to target a specified rate of return. In such cases, that rate of return can be applied as the discount rate for the NPV calculation. In this way, a direct comparison can be made between the profitability of the project and the desired rate of return. The interest rate used to discount future income flows to their present values is a key input of this process. Most firms have a well-defined policy regarding their capital structure. So the weighted average cost of capital (after tax) is appropriate for use in all projects.

n be used for more risky projects. Another method is to apply higher discount rates to income flows occurring further along the time span, to reflect the yield curve premium for long-term debt.

b.Availability of Capital

It is assumed that a positive NPV will be adopted regardless of the capital required. Capital is assumed to be readily available, no matter how much is needed or what are the constraints. This is rarely the case because access to capital markets is limited according to the overall performance of the company. Therefore, large NPVs may be foregone, given the capital requirements.

c.Option Investments

The capital requirements may change over time, requiring decisions along the way that may change the risk profile. NPV uses information known at the time of the completion of the analysis. It is calculated in a static manner that does not allow for any future changes. The rigidity of this assumption will lead to underestimation of values.

*d.Reinvestment rate :*There are assumptions made about what rate of return is realized on cash that is freed-up before the end of the project. In the NPV model it is assumed to be reinvested at the discount rate used. This is appropriate in the absence of capital rationing. In the IRR model, no assumption is made about the reinvestment rate of free cash, which tends to exaggerate the calculated values. Some people believe that if the firm's reinvestment rate is higher than the Weighted Average Cost of Capital, it becomes, in effect, an opportunity cost and should be used as the discount rate.

t it does not require an explicit assumption about the return to invested capital associated with the resource.

Appropriation Method

In many countries, governments are the primary owners of the nation's natural resources. As landowners, governments collect the entire rent derived from extraction of the resources they own. Resource rent is normally collected by governments through fees, taxes and royalties levied on companies that carry out extraction. One way of estimating the economic rent attributable to a resource is to equate this with the fees, taxes and royalties collected from the companies involved in the resource extraction. However, in practice, fees, taxes and royalties tend to understate resource rent as they may be set by governments with other priorities in mind; for instance, implicit price subsidies to extractors, and encouraging employment in the industry. Also, the rate of payments to government may not move in line with market prices for the extracted product though one would expect the true economic rent to do so. When these data are not separately identifiable, or suitable, resource rent must be imputed using various indirect methods. However, if the two sets of data are available, publishing a comparison of the values may be useful for economic policy analysis. (SEEA, 2003)

3.3. The Cost Approach

40. The cost approach provides an alternative way of valuing mineral assets. This is used to value depletion which considers the cost needed to replace a certain mineral assets.

on how much asset plus or minus a discount or premium as the case may be e.g. replacement cost less accrued depreciation.

The Appraised Value Method

The Appraised Value Method is based on the premise that the real value of an exploration property or a marginal development property lies in its potential for the existence and discovery of an economic mineral deposit. The Appraised Value Method assumes that the amount of exploration expenditure justified on a property is related to its value. The cost approach is given some validity by the fact that option agreements on mineral properties are often based on expenditures required to earn an interest.

The basic tenet of the appraised value method is that an exploration property is worth the meaningful past exploration expenditures plus warranted future cost. . An important element of this method, which is often overlooked in its application, is that only those past expenditures which are considered reasonable and productive are retained as value. Productive means that the results of the work give sufficient encouragement to warrant further work by identifying potential for the existence and discovery of an economic mineral deposit. Warranted future costs comprise a reasonable exploration budget to test the identified potential, which can be geophysical or geochemical anomalies, or promising showings or mineralized zones already identified. As noted previously, if exploration work downgrades potential, it is not productive and its cost should not be retained as value or should be reduced. Obviously, if the property is considered to have negligible exploration potential, it has little or no value.

ed on an annual basis. In times of high inflation, past expenditures are escalated to the effective date of valuation or current unit costs are applied to the work retained. Usually little of the expenditures more than five or so years prior to the effective valuation date are retained.

In the case of dual or multiple property ownership, the Appraised Value of the whole property is determined first. Then the value is apportioned to one or more of the property owners. During an option or earn-in period, the property interests of each party are assumed to be the final earned interests. Some properties carry a royalty, commonly as a net smelter return or net profits interest. Such royalties are deducted as a pro rata percentage from the Appraised Value apportioned to the non-royalty holder. This is done to recognize the existence of the royalty and is not meant to imply a value for the royalty. In some cases it may be necessary to differentiate between a net smelter return and net profits interest royalty by using a higher percentage for the former relative to the latter.

The derivation of an appraised value by adding the retained past expenditures to the warranted future costs should be thought of as an abstract exercise to determine the cost of an exploration óplayô on a property, which is considered to be the Appraised Value. It should not be thought of in terms of who pays for the future exploration program, although it is similar to the earn-in aspect of some option agreements. It should also not be thought of as an accounting exercise where exploration expenditures are booked and can be written off over time or against income.

Limitations

est applied to properties which are actively being explored. It is more difficult to apply the method to properties that have been idle for some years, especially those which have had substantial expenditures in the past. The key to the valuation of inactive properties is a realistic assessment of the remaining exploration potential, which could be in the form of untested targets, potential to increase the grade or tonnage of the existing resource, or potential for development with changes in technology or economic conditions.

The Appraised Value may have to be adjusted to Fair Market Value if the local market for properties is markedly depressed or markedly high as of the effective date of the valuation. These conditions can be recognized by applying a subjective market factor, usually in increments of 25%, as either a discount or a premium to the Appraised Value. A premium may be applied to the Appraised Value to recognize an advantageous location such as proximity and geological similarity to an operating mine or new discovery.

One advantage of the Appraised Value Method is that exploration cost information and technical data are readily available for most exploration properties and marginal development properties. It is a good way of comparing the relative values of exploration properties. The main disadvantage is that experienced judgment is required to separate the past expenditures considered to be productive from those considered not to contribute to the value of the property, and to assess what is a reasonable future exploration program and cost. This leaves the method open to misuse and possible abuse.

The Contingent Valuation Method

(CVM) is an economic, non-market based valuation method especially used to infer individualôs preferences for public goods, notably environmental quality. It was first proposed in theory by S.V. Ciriacy-Wantrup (1947) (Wikipedia, URL) as a method for eliciting market valuation of a non-market good. The work was published in the Journal of Farms Economics. It is a survey-based economic technique for the valuation of non-market resources, such as environmental preservation or the impact of contamination. While these resources do give people utility, certain aspects of them do not have a market price as they are not directly sold ï for example, people receive benefit from a beautiful view of a mountain, but it would be difficult to value using price-based models. Contingent valuation surveys are one technique which is used to measure these aspects. Contingent valuation is often referred to as a *stated preference* model (Wikipedia, URL), in contrast to a price-based *revealed preference* model. Both models are utility-based. Typically the survey asks how much money people would be willing to pay to maintain the existence of (or be compensated for the loss of) an environmental feature, such as biodiversity.

The first practical application of the technique was in 1963 when Davis used surveys to estimate the value hunters and tourists placed on a particular wilderness area. He compared the survey results to an estimation of value based on travel costs and found good correlation with his results.

method rose to high prominence in the 1980s when government agencies were given the power to sue for damage to environmental resources which they were trustees over.

Many economists question the use of stated preference to determine willingness to pay for a good, preferring to rely on people's revealed preferences in binding market transactions. Early contingent valuation surveys were often open-ended questions of the form "how much compensation would you demand for the destruction of X area" or "how much would you pay to preserve X". Such surveys potentially suffer from a number of shortcomings; strategic behaviour, protest answers, response bias and respondents ignoring income constraints.[1] Early surveys used in environmental valuation seemed to indicate people were expressing a general preference for environmental spending in their answers, described as the embedding effect by detractors of the method.

In this method, the following conditions are required:

- Personal interviews should be used to conduct the survey, as opposed to telephone or mall-stop methods.
- Surveys should be designed in a yes or no referendum format put to the respondent as a vote on a specific tax to protect a specified resource.
- Respondents should be given detailed information on the resource in question and on the protection measure they were voting on. This information should include

and worst-case scenarios), scientific evaluation of its ecological importance and possible outcomes of protection measures.

- Income effects should be carefully explained to ensure respondents understood that they were to express their willingness to pay to protect the particular resource in question, not the environment generally.
- Subsidiary questions should be asked to ensure respondents understood the question posed.

The guiding principle behind these recommendations was that the survey operator has a high burden of proof to satisfy before the results can be seen as meaningful.

The typical CVM survey consists of three sections.

The first section is characterized by the description of the environmental change as conveyed by the policy formulation and the description of the contingent market.

The third section of the CVM instrument is a set of questions that collect socio-demographic information about the respondents.

The second section is where the respondent is asked to state her monetary valuation for the described policy formulation.

ation methodology corrects for these shortcomings, and current empirical testing indicates that such bias and inconsistency has been successfully addressed.[2]

As shown by Mundy and McLean (1998), contingent valuation is now widely accepted as a real estate appraisal technique, particularly in contaminated property or other situations where revealed preference models (i.e. transaction pricing) fail due to disequilibrium in the market.[3] McLean, Mundy, and Kilpatrick (1999) demonstrate the acceptability of contingent valuation in real estate expert testimony,[4] and the current standards for use of contingent valuation in litigation situations is described by Diamond (2000).[5]

There are a set of guidelines in the application of CVM applications, concerning the design and execution of the survey instrument. These are summarized below:

1. CVM should rely on face-to-face interviews rather than telephone interviews, and whenever this is not possible (specially because of the high costs associated with the personal interviews) telephone interviews are preferable to mail surveys;
2. CVM should elicit the respondentôs WTP to prevent a future incident rather than WTA (Willingness to Accept) for an incident already occurred;
3. CVM should use a dichotomous choice referendum elicitation format, i.e., the respondents should be asked how they would vote (favour or against) upon a described environmental quality change. The main reason for the dichotomous choice is that such a take-it-or-leave-it survey valuation question is more likely to

ket decisions which individuals are confronted with. Moreover, the dichotomous choice referendum reveals itself to be less vulnerable to strategic bidding behaviour than, for example, the open ended elicitation format;

4. CVM should contain an accurate and understandable description of the program or policy under consideration and the associated environmental benefits in each of the two scenarios, i.e., with and without the policy. Interdisciplinary work with other research areas, namely the biological sciences, is recommended;
5. CVM should include reminders of the substitutes for the commodity in question as well as its budget. In a context where the respondents are being asked how they would vote on a financial contribution to protect a natural area, the respondents should be reminded of the existence of the other areas that exist. Moreover the respondent should be reminded that such contribution would reduce the amount of money that he or she has available to spend on other things. The major idea here is to make such a (hypothetical) valuation exercise resemble as closely as possible an actual market transaction;
6. CVM experiments should include a follow-up section at the end of the questionnaire to be sure if the respondents understood (or not) the choice that they were asked to make.
7. Cost–benefit analysis

ates and totals up the equivalent money value of the benefits and costs to the community of projects to establish whether they are worthwhile. These projects may be dams and highways or can be training programs and health care systems.(*Watkins,*ValleyandAlley,URL)

Cost–benefit analysis (CBA), sometimes called benefit–cost analysis (BCA), is a systematic process for calculating and comparing benefits and costs of a project, decision or government policy (hereafter, "project"). CBA has two purposes:

1. To determine if it is a sound investment/decision (justification/feasibility),
2. To provide a basis for comparing projects. It involves comparing the total expected cost of each option against the total expected benefits, to see whether the benefits outweigh the costs, and by how much.[1]

The concept of CBA dates back to an 1848 article by Jules Dupuit and was formalized in subsequent works by Alfred Marshall.CBA is related to, but distinct from cost-effectiveness analysis. In CBA, benefits and costs are expressed in money terms, and are adjusted for the time value of money, so that all flows of benefits and flows of project costs over time (which tend to occur at different points in time) are expressed on a common basis in terms of their "net present value."

Costï benefit analysis is often used by governments and others, e.g. businesses, to evaluate the desirability of a given policy. It is an analysis of the expected balance of benefits and costs, including an account of foregone alternatives and the *status quo*, of a policy outweigh its costs, and by how much (i.e. one can rank alternate policies in terms of the ratio of costs and benefit).[citation needed] Altering the status quo by choosing the lowest cost-benefit ratio can improve pareto efficiency,[citation needed] in which no alternative policy can improve one group's situation without damaging another. Generally, accurate cost-benefit analysis identifies choices that increase welfare from a utilitarian perspective. Otherwise, cost-benefit analysis offers no guarantees of increased economic efficiency or increases of social welfare; generally positive microeconomic theory is moot when it comes to evaluating the impact on social welfare of a policy.[citation needed]

STEPS

The following is a list of steps that comprise a generic cost-benefit analysis.[2]

1. List alternative projects/programs.
2. List stakeholders.
3. Select measurement(s) and measure all cost and benefits elements.
4. Predict outcome of cost and benefits over relevant time period.
5. Convert all costs and benefits into a common currency.
6. Apply discount rate.
7. Calculate net present value of project options.
8. Perform sensitivity analysis.
9. Adopt recommended choice.

One of the problems of CBA is that the computation of many components of benefits and costs is intuitively obvious but that there are others for which intuition fails to suggest methods of measurement. Therefore some basic principles are needed as a guide.

There Must Be a Common Unit of Measurement

The choice of the appropriate interest rate to use for the discounting is a separate issue that will be treated later in this paper.

CBA Valuations Should Represent Consumers or Producers Valuations As Revealed by Their Actual Behavior

Benefits Are Usually Measured by Market Choices

Gross Benefits of an Increase in Consumption is an Area Under the Demand Curve

Some Measurements of Benefits Require the Valuation of Human Life

Decision Criteria for Projects

Cost Benefit Analysis Involves a Particular Study Area

Double Counting of Benefits or Costs Must be Avoided

The Analysis of a Project Should Involve a *With* Versus *Without* Comparison

5.0 Conclusion

6.0 References/Further Reading

Accounting for Subsoil Mineral Resources Survey of Current Business, February 2000. Found at: http://www.bea.gov/scb/pdf. Accessed date: February 22, 2007.

Braband, D., Geier, U. and Köpke, U. (2003): Bio-resource evaluation within agri-environmental assessment tools in different European countries. *Agriculture, Ecosystems and Environment 98* (2003) 423ï 434

Wikipedia, the free encyclopedia: http://en.wikipedia.org/wiki/Mineral_exploration

Domingo, E. V. and E. E. P. Lopez-Dee (2007): Valuation Methods of Mineral Resources. 11th Meeting of the London Group on Environmental Accounting, Johannesburg, 26-30 March 2007.

Wikipedia, the free encyclopedia:http://en.wikipedia.org/wiki/Contingent_valuation

Carson, Carol S. 1994. Accounting For Mineral Resources: Issues and BEA's Initial Estimates. (Bureau of Economic Analysis). Found at: http://www.encyclopedia.com/doc/1G1-15280053.html. Accessed date: February 22, 2007.

Farzin Y. Hossein. The Effect of the Discount Rate on Depletion of Exhaustible Resources;

, Vol. 92, No. 5 (Oct., 1984), pp. 841-851. Found at: http://links.jstor.org/sici?sici=0022-3808%28198410%2992%3A5%3C841%3ATEOTDR%3E2.0.CO%3B2-N&size=LARGE&origin=repec. Accessed date; March 15, 2007

Khanna, Nelia, 2001.On the Economics of Non-Renewable Resources. Found at: Http://www.binghamton.edu.wp)/WPO102.pdf. Accessed date: February 23, 2007

1. ^ Peter A. Diamond; Jerry A. Hausman, 'Contingent Valuation: Is Some Number better than No Number?' *The Journal of Economic Perspectives*, Vol. 8, No. 4. (Autumn, 1994), pp. 45-64
2. ^ See, for example, [[Bill Mundy (real estate)|]] and Dave McLean, The Addition of Contingent Valuation and Conjoint Analysis to the Required Body of Knowledge for the Estimation of Environmental Damage to Real Estate, *The Journal of Real Estate Practice and Education*, 1998, http://www.greenfieldadvisors.com/publications/contingentvaluation.pdf
3. ^ Dave McLean, [[Bill Mundy (real estate)|]], and John A. Kilpatrick, Summation of Evidentiary Rules for Real Estate Experts Mandated by Daubert v. Merrill Dow Pharmaceuticals, *Real Estate Issues*,1999, http://www.greenfieldadvisors.com/publications/sumevid.pdf

T; Wilks, Leanne; Imber, David "Valuing the Preservation of Australia's Kakadu Conservation Zone" (1994) *Oxford Economic Papers*, vol. 46(0), pp. 727-49

5. ^ Kilpatrick, John A., Valuation of Brownfields, Chapter 29 in Lexis-Nexis Matthew Bender's *Brownfield Law and Practice*, 2007

- W. Michael Hanemann, 'Valuing the Environment Through Contingent Valuation' *The Journal of Economic Perspectives*, Vol. 8, No. 4. (Autumn, 1994), pp. 19-43
- Paul R. Portney, 'The Contingent Valuation Debate: Why Economists Should Care' *The Journal of Economic Perspectives*, Vol. 8, No. 4. (Autumn, 1994), pp. 3-17
- Nunes, P.A.L.D. and J.C.J.M. van den Bergh (2004) ñValuing non-market benefits for protection against exotic marine species in the Netherlands using TC and CV dataò, Environment and Resource Economics, 28, pp. 517-532.
- Mitchell, R. C. and R. T. Carson (1989) ñUsing Surveys to Value Public Goods. The Contingent Valuation Method]ò, Washington DC, Resources for the Future.

Watkins,T., Valley, S. and Alley, T. (URL)Introduction to Cost ï Benefit Analysis http://www.sjsu.edu/faculty/watkins/cba.htm

MODULE 4 [GEOMORPHOLOGICAL TECHNIQUES]

Unit 1 Introduction

1.0 Introduction

In this module, the geomorphological techniques relevant to resources evaluation are considered. In this case, and in this first unit, it is expedient to introduce the subject matter of geomorphology generally with a view to enhancing understanding of the different techniques which shall be discussed later in the module. Since the module is on geomorphological techniques, it makes sense to introduce quantitative geomorphology and the geomorphological processes which the different techniques are meant to analyze and address.

2.0 Objectives

a. To give a general introduction on the evolution of geomorphological techniques the geomorphological processes

c. To expose the students to quantitative geomorphology relevant to resources evaluation.

3.0 Main Body

3.1 Meaning of Geomorphology

According to Wikipedia (URL) geomorphology is the scientific study of landforms and the processes that shape them. It seeks to understand why landscapes look the way they do, to understand landform history and dynamics, and to predict future changes through a combination of field observations, physical experiments, and numerical modeling. Land itself is a resource and the processes that shape the form of the land and its resources can certainly degrade it. Consequently, in resource evaluation, techniques of addressing the different processes and the problems associated with them needs be studied.

3.2 Geomorphological Processes

a. Fluvial processes

Rivers and streams are not only conduits of water, but also of sediment (Wikipedia, URL). The water, as it flows over the channel bed, is able to mobilize sediment and transport it downstream, either as bed load, suspended load or dissolved load. The rate of sediment transport is a function of the availability of sediment itself and the discharge of the river itself Knighton (1998).

nto rock and creating new sediment, both from their own beds and also by coupling to the surrounding hillslopes. In this way, rivers are thought of as setting the base level for large scale landscape evolution in nonglacial environments (Burbank, 2002, in Wikipedia, URL). Rivers are key links in the connectivity of different landscape elements.

As rivers flow across the landscape, they generally increase in size, merging with other rivers. The network of rivers thus formed is a drainage system and is often dendritic, but a different pattern may result depending on the regional topography and underlying geology.

b. Eolian processes

Eolian processes have to do with the activity of the winds and their ability to shape the surface of the Earth. Winds are capable of eroding, transporting, and depositing materials, and are effective agents in regions where vegetation is sparse and also where there is a large supply of unconsolidated sediments. Although water and mass flow tend to mobilize more material than wind in most environments, eolian processes are important in arid environments such as deserts (Gabet, et al, 2003)

Mesquite Flat Dunes in Death Valley looking toward the Cottonwood Mountains from the north west arm of Star Dune (2003) in Wikipedia, URL).

d. Hillslope processes

ro Canyon, Texas (Wikipedia, URL).

Soil, regolith, and rock move downslope under the force of gravity through creep, slides, flows, topples, and falls. Such mass wasting occurs on both terrestrial and submarine slopes, and has been observed on Earth, Mars, Venus, Titan and Iapetus.

Ongoing hillslope processes can change the topology of the hillslope surface, which in turn can change the rates of those processes. Hillslopes that steepen up to certain critical thresholds are capable of shedding extremely large volumes of material very quickly, making hillslope processes an extremely important element of landscapes in tectonically active areas (Church and Ryder, 1972)

e. Glacial processes

Features of a glacial landscape (Wikipedia, URL)

Glaciers are geographically restricted as well as being effective agents of landscape change. When ice gradually moves down a valley, it results in abrasion and plucking of the underlying rock. Abrasion produces fine sediment known as glacial flour. The debris transported by the glacier, when the glacier recedes, is termed a moraine. According to Dietrich and Perron (2006) glacial erosion is responsible for U-shaped valleys, as opposed to the V-shaped valleys of fluvial origin.

f. Tectonic processes

can range from scales of millions of years to minutes or less. The effects of tectonics on landscape depend heavily on the nature of the underlying bedrock fabric that more or less controls what kind of local morphology tectonics can shape (Wikipedia, URL). Earthquakes can, in terms of minutes, submerge large extensions creating new wetlands. Isostatic rebound can account for significant changes over thousand or hundreds of years, and allows erosion of a mountain belt to promote further erosion as mass is removed from the chain and the belt uplifts (Wikipedia, URL).

Features of deeper mantle dynamics such as plumes and delamination of the lower lithosphere have also been hypothesised to play important roles in the long term (> million year), large scale (thousands of km) evolution of the Earth's topography (Wikipedia, URL).. Both can promote surface uplift through isostasy as hotter, less dense, mantle rocks displace cooler, denser, mantle rocks at depth in the Earth.

g. Igneous processes

igneous processes like Villarrica National Park in the picture (Wikipedia, URL).

Both volcanic (eruptive) and plutonic (intrusive) igneous processes can have important impacts on geomorphology. The action of volcanoes tends to rejuvenize landscapes, covering the old land surface with lava and tephra, releasing pyroclastic material and forcing rivers through new paths. The cones built by eruptions also build substantial new topography, which can be acted upon by other surface processes.

h. Biological processes

Beaver dams, as this one in Tierra del Fuego, constitute a specific form of zoogeomorphology, a type of biogeomorphology (Wikipedia, URL).

The interaction of living organisms with landforms, or biogeomorphologic processes, can be of many different forms, and is probably of profound importance for the terrestrial ogy can influence very many geomorphic processes, ranging from biogeochemical processes controlling chemical weathering, to the influence of mechanical processes like burrowing and tree throw on soil development, to even controlling global erosion rates through modulation of climate through carbon dioxide balance. Terrestrial landscapes in which the role of biology in mediating surface processes can be definitively excluded are extremely rare, but may hold important information for understanding the geomorphology of other planets, such as Mars.

3.3 Quantitative geomorphology

Quantitative geomorphology emerged as a result of the early work of Grove Karl Gilbert around the turn of the 20th century. According to Wikipedia (URL), a group of natural scientists, geologists and hydraulic engineers including Ralph Alger Bagnold, John Hack, Luna Leopold, Thomas Maddock and Arthur Strahler started to research on the form of landscape elements such as rivers and hillslopes by making systematic, direct, quantitative measurements of aspects of them and investigating the scaling of these measurements. These methods began to allow prediction of the past and future behavior of landscapes from present observations, and were later to develop into what the modern trend of a highly quantitative approach to geomorphic problems. Quantitative geomorphology consequently involve techniques like fluid dynamics and solid mechanics, geomorphometry, laboratory studies, field measurements, theoretical work, and full landscape evolution modeling. These approaches are used to understand oils, sediment transport, landscape change, and the interactions between climate, tectonics, erosion, and deposition.

4.0 Summary

From the foregoing facts, it is clear what quantitative geomorphology means. Also, the different processes including fluvial, eolian, hillslope, glacial, tectonic, igneous and biological processes which sum up the subject matter of geomorphology were briefly discussed. With the understanding from these, the different techniques are presented in the units that follow

5.0 Conclusion

This unit gave a general introduction to geomorphology with bias on quantitative geomorphology and the processes involved in geomorphology.

6.0 References/Further Reading

Allen, 2008, Time scales of tectonic landscapes and their sediment routing systems, Geol. Soc. Lon. Sp. Pub., v. 296, p.7-28.

Bennett, M.R. & Glasser, N.F., 1996, Glacial Geology: Ice Sheets and Landforms, John Wiley & Sons Ltd, 364 p. ISBN 0-471-96345-3.

Benda & Dunne, 1997, Stochastic forcing of sediment supply to channel networks from landsliding and debris flow, Water Resources Res., v. 33(12), p. 2849-2863.

erosion and their implications for exhumation: Mineralogical Magazine, v. 66, p. 25-52.

Church, M. and Ryder, J.M., 1972, Conditioned by GlaciationParaglacial Sedimentation: A Consideration of Fluvial Processes Conditioned by Glaciation, Geological Society of America Bulletin, v. 83, p. 3059-3072.

Dietrich et al., 2003, Geomorphic Transport Laws for Predicting Landscape Form and Dynamics, AGU Geophysical Monograph 135, p. 1-30.

Gabet, E.J., Reichman, O.J., Seabloom, E.W., 2003, The Effects of Bioturbation on Soil Processes and Sediment Transport, Ann. Rev. Earth Planet. Sci., v. 31, p. 249-273.

Knighton, D., 1998, Fluvial Forms & Processes, Hodder Arnold, 383 p. ISBN 0-340-66313-8.

Leeder, M., 1999, Sedimentology and Sedimentary Basins, From Turbulence to Tectonics, Blackwell Science, 592 p. ISBN 0-632-0497-6.

Roe et al., 2008, Feedbacks among climate, erosion and tectonics in a critical wedge orogen, Am. J. Sci., v. 308(7), p. 815-842.

Willett & Brandon, 2002, On Steady States in Mountain Belts, Geology, v. 30(2), p. 175-178.

Strahler, A.N., 1950, Equilibrium theory of erosional slopes approached by frequency distribution analysis, Am. J. Sci., v. 248, p. 673-696.

eomorphology. Page 4. 1985

Whipple, 2004, Bedrock Rivers and the Geomorphology of Active Orogens, Anu. Rev. Earth Planet. Sci., v. 32, p. 151-185.

Unit 2 Geomorphometry

1.0 Introduction

In this unit, the aspect of quantitative geomorphology known as geomorphometry will be discussed. This technique involves the quantitative analysis of the land surface. The principles of the technique as well as application are presented in this section.

2.0 Objectives

a. To expose the students to the technique of geomorphometry.

b. To get the students to understand the principles of geomorphometry.

3.0 Main Body

3.1 Geomorphometry

3.1.2 Meaning and Overview

Geomorphometry is the science of quantitative land-surface analysis (Pike, 1995, 2000a; Rasemann et al., 2004 in Pike, Evans and Hengl, 2009). According to the work as cited from Tobler (1976, 2000), it is a modern, analytical-cartographic approach to representing bare-earth topography by the computer manipulation of terrain height. Pike, work looks at Geomorphometry as the science of topographic quantification; its operational focus is the extraction of land-surface parameters and objects from digital elevation models (DEMs). Geomorphometry is an interdisciplinary field that has evolved from mathematics, the Earth sciences, and ð most recently ð computer science. Although geomorphometry has been regarded as an activity within more established fields, geography and geomorphology, soil science and military engineering, recently, it has evolved as a discipline in its own right. (Pike, 1995 in Pike, Evans and Hengl, 2009).

It is well to keep in mind the two overarching modes of first distinguished by Evans (1972) identified and actually distinguished between two modes of geomorphometric analysis: specific, which addresses discrete surface features (i.e. landforms), and general, which deals with the continuous land surface. Most books of Geomorphometry principally deals with the computer characterisation and analysis of continuous topography (for an example see Pike, Evans and Hengl, 2009).

Central to geomorphometry is the numerical representation of the land surface which some authors refer to as terrain modelling (example Pike, Evans and Hengl, 2009 and Li et al., 2005), while some others call terrain analysis (Wilson and Gallant, 2000), and still others like Mark and Smith (2004) call it the science of topography. The word terrain things to different people. It may be associated with land form, hydrographic features, soil, vegetation, and geology. It may also be used to refer to the socio-economic aspects of an area (Li et al., 2005). Terrain also can signify an area of ground, a region . . . unrelated to shape of the land surface (Pike, Evans and Hengl, 2009). Allder et al., (1982) in Pike, Evans and Hengl (2009) remarked that Digital elevation model (DEM) has become the favoured term for the data most commonly input to geomorphometry, ever since the U.S. Geological Survey (USGS) first began distribution of 3-arc-second DEMs in 1974. The square-grid representation is usually used as input in geomorphometric analysis of the land surface. This model is what is referred to as a digital elevation model (DEM) or digital land surface model (DEM or DLSM). In terrain modeling, series of X, Y and Z coordinates are used. When the Z values refer specifically to land surface characteristics (altitude), the the term digital elevation model (DEM) is appropriately used, but when the Z value include other things like socio-economic characteristics, the generic term digital terrain model (DTM)is used.

3.1.2 The Basic Principles of Geomorphometry

According to Pike, Evans and Hengl (2009) the fundamental operation in geomorphometry is extraction of parameters and objects from DEMs DEMs, are the primary input to morphometric analysis. According to the authors, ñin GIS (geographic s simply a raster or a vector map showing the height of the land surface above mean sea level or some other referent horizon. Geomorphometry commonly is implemented in five steps (After Pike, Evans and Hengl, 2009).

a. Sampling the land surface (height measurements).

b. Generating a surface model from the sampled heights.

c. Correcting errors and artefacts in the surface model.

d. Deriving land-surface parameters and objects.

e. Applications of the resulting parameters and objects.

Land-surface parameters are grouped into three namely:

a. Basic morphometric parameters and objects (see Pike, Evans and Hengl, 2009, Chapter 6);

b. Parameters and objects specific to hydrology (see Pike, Evans and Hengl, 2009, Chapter 7);

c. Parameters and objects specific to climate and meteorology (see Pike, Evans and Hengl, 2009, Chapter 8).

FIGURE 2 The operational focus of geomorphometry is extraction of land-surface parameters and objects from DEMs.

Source: Pike, Evans and Hengl (2009)

4.0 Summary

The geomorphological technique called geomorphometry was discussed here. The digital elevation model was identified as the major input source of data for its analysis.

5.0 Conclusion

Geomorphometry was discussed here.

6.0 References/Further Reading

Mark, D.M., Smith, B., 2004. A science of topography: from qualitative ontology to digital representations. In: Bishop, M.P., Shroder, J.F. (Eds.), Geographic Information Science and Mountain Geomorphology. Springerï Praxis, Chichester, England, pp. 75ï 97.

terrain modeling (geomorphometry), the quantitative representation of topographyð supplement 4.0. Open-File Report 02-465. U.S. geological Survey, Denver, 116 pp. http://geopubs.wr.usgs.gov.

Pike, R.J., 2000. Geomorphometry ð diversity in quantitative surface analysis. Progress in Physical Geography 24 (1), 1ï 20.

Zhou, Q., Lees, B., Tang, G. (Eds.), 2008. Advances in Digital Terrain Analysis. Lecture Notes in Geoinformation and Cartography Series. Springer, 462 pp.

http://geomorphometry.org ð the geomorphometry research group.

Unit 3 Seismic Techniques

1.0 Introduction

In this unit, seismic techniques are presented. Under this, the refraction and reflection techniques are considered. The advantages and disadvantages of each have been highlighted as well. Important Issues surrounding these techniques are discussed in this unit.

2.0 Objectives

a. To get the students to understand the different seismic techniques the refractive as well as reflective techniques can be applied in problem solving.

c. To expose the students to the advantages and disadvantages of the different seismic techniques.

3.0 Main Body

3.1 Seismic Techniques

3.1.1 Refraction Methods

Seismic refraction is a geophysical principle which works based on Snell's Law. Snell's law (also known as law of refraction) in optics, is a formula used to describe the relationship between the angles of incidence and refraction, when referring to light or other waves passing through a boundary between two different isotropic media, such as water and glass. It is used in the fields of engineering geology, geotechnical engineering and exploration geophysics. Seismic refraction traverses are carried out using a seismograph(s) and/or geophone(s), in an array and an energy source (Wikipedia, URL). This technique utilizes the refraction of seismic waves on geologic layers and rock/soil units in order to characterize the subsurface geologic conditions and geologic structure. According to Kesel (2005) the portable refraction seismograph provides a useful research tool for determining the characteristics and thickness of surficial waste covers. Several types of instruments are used.

methods depend on the fact that seismic waves have differing velocities in different types of soil (or rock). The waves are refracted when they cross the boundary between different types (or conditions) of soil or rock. The methods enable the general soil types and the approximate depth to strata boundaries, or to bedrock, to be determined.

There are two types of refraction methods namely, the P-Wave Refraction (Compression Wave Refraction) and S-Wave Refraction (Shear Wave Refraction). The P-wave refraction evaluates the compression wave generated by the seismic source located at a known distance from the array. The wave is generated by vertically striking a striker plate with a sledgehammer, shooting a seismic shotgun into the ground, or detonating an explosive charge in the ground. Since the compression wave is the fastest of the seismic waves, it is sometimes referred to as the primary wave and is usually more-readily identifiable within the seismic recording as compared to the other seismic waves.

On the other hand, the S-wave refraction evaluates the shear wave generated by the seismic source located at a known distance from the array. The wave is generated by horizontally striking an object on the ground surface to induce the shear wave. Since the shear wave is the second fastest wave, it is sometimes referred to as the secondary wave. When compared to the compression wave, the shear wave is approximately one-half (but may vary significantly from this estimate) the velocity depending on the medium.

This technique employs fewer source and receiver locations and are therefore relatively cheap to acquire.

a. Refraction observations require little observation with the exception of trace scaling or filtering which helps in picking the time of arrival of the initial ground motion.

b. Since a small portion ground motion is recorded and used, it is easy to develop models and interpretations compared to other geophysical surveys.

Disadvantages (After http://www.earthsci.unimelb.edu.au/ES304/MODULES/SEIS/NOTES/sadv2.html)

a. Refraction seismic observations require relatively large source-receiver offsets (distances between the source and where the ground motion is recorded, the receiver).

b. Refraction seismic only works if the speed at which motions propagate through the Earth increases with depth.

c. Refraction seismic observations are generally interpreted in terms of layers. These layers can have dip and topography.

d. Refraction seismic observations only use the arrival time of the initial ground motion at different distances from the source (that is, offsets).

e. A model for the subsurface is constructed by attempting to reproduce the observed arrival times.

3.1.2 Reflection Methods

Reflection seismology (or seismic reflection) is a geophysical exploration method that makes use of the principles of seismology to estimate the properties of the Earth's subsurface from reflected seismic waves. This method requires a controlled seismic source of energy, such as dynamite/Tovex, a specialized air gun or a seismic vibrator, commonly known by the trademark name Vibroseis (Wikipedia, URL). Reflection seismology is similar to sonar and echolocation.

Seismic waves are mechanical perturbations that travel in the Earth. Any medium that can support wave propagation may be described as having an impedance The seismic (or acoustic) impedance Z is defined by the equation

$$Z=V\rho,$$

where V is the seismic wave velocity and ρ (Greek rho) is the density of the rock. When a seismic wave encounters a boundary between two different materials with different impedances, some of the energy of the wave will be reflected off the boundary, while some of it will be transmitted through the boundary.

A reflection experiment is carried out by initiating a seismic source (such as a dynamite explosion) and recording the reflected waves using one or more seismometers. On land, the typical seismometer used in a reflection experiment is a small, portable instrument known as a geophone, which converts ground motion into an analog electrical signal. In pressure changes into electrical signals, are used. As the seismometers detect the arrival of the seismic waves, the signals are converted to digital form and recorded; early systems recorded the analog signals directly onto magnetic tape, photographic film, or paper. The signals may then be displayed by a computer as seismograms for interpretation by a seismologist. Typically, the recorded signals are subjected to significant amounts of signal processing and various imaging processes before they are ready to be interpreted. In general, the more complex the geology of the area under study, the more sophisticated are the techniques required to perform the data processing. Modern reflection seismic surveys require large amounts of computer processing, often performed on supercomputers or on computer clusters.

Reflection and transmission

When a seismic wave encounters a boundary between two materials with different impedances, some of the energy in the wave will be reflected at the boundary, while some of the energy will continue through the boundary. The amplitude of the reflected wave is predicted by multiplying the amplitude of the incoming wave by the seismic reflection coefficient R, determined by the impedance contrast between the two materials.

For a wave that hits a boundary at normal incidence (head-on), the expression for the reflection coefficient is simply

,

where Z0 and Z1 are the impedance of the first and second medium, respectively.

ncoming wave is multiplied by the transmission coefficient to predict the amplitude of the wave transmitted through the boundary. The formula for the normal-incidence transmission coefficient (the ratio of transmitted to incident pressure amplitudes) is

.

As the sum of the amplitudes of the reflected and transmitted wave has to be equal to the amplitude of the incident wave, it is easy to show that

.

By observing changes in the strength of reflectors, seismologists can infer changes in the seismic impedances. In turn, they use this information to infer changes in the properties of the rocks at the interface, such as density and elastic modulus.

For non-normal incidence (at an angle), a phenomenon known as mode conversion occurs. Longitudinal waves (P-waves) are converted to transverse waves (S-waves) and vice versa. The transmitted energy will be bent, or refracted, according to Snell's law. The expressions for the reflection and transmission coefficients are found by applying appropriate boundary conditions to the wave equation, a topic beyond the scope of this article. The resulting formulas, first determined at the beginning of the 20th century, are known as the Zoeppritz equations. The reflection and transmission coefficients govern the signal strength (amplitude) at each reflector. The coefficients at a given angle of incidence vary with (among many other things) the fluid content of the rock. Practical use

, known as AVO (amplitude versus offset) has been facilitated by theoretical work to derive workable approximations to the Zoeppritz equations, and by advances in computer processing capacity. AVO studies attempt with some success to predict the fluid content (oil, gas, or water) of potential reservoirs, to lower the risk of drilling unproductive wells and to identify new petroleum reservoirs.

Interpretation of reflections

The time it takes for a reflection from a particular boundary to arrive at the geophone is called the travel time. If the seismic wave velocity in the rock is known, then the travel time may be used to estimate the depth to the reflector. For a simple vertically traveling wave, the travel time t from the surface to the reflector and back is called the Two-Way Time (TWT) and is given by the formula

,

where d is the depth of the reflector and V is the wave velocity in the rock.

A series of apparently related reflections on several seismograms is often referred to as a reflection event. By correlating reflection events, a seismologist can create an estimated cross-section of the geologic structure that generated the reflections. Interpretation of large surveys is usually performed with programs using high-end three dimensional computer graphics.

Reflection seismology is extensively used in exploration for hydrocarbons (i.e., petroleum, natural gas) and such other resources as coal, ores, minerals, and geothermal o used for basic research into the nature and origin of the rocks making up the Earth's crust. Reflection Seismology is also used in shallow application for engineering, groundwater and environmental surveying. A method similar to reflection seismology which uses electromagnetic instead of elastic waves is known as Ground-penetrating radar or GPR. GPR is widely used for mapping shallow subsurface (up to a few meters deep).

Environmental impact

As with all human activities, reflection seismic experiments may impact the Earth's natural environment. On land, conducting a seismic survey may require the building of roads in order to transport equipment and personnel. Even if roads are not required, vegetation may need to be cleared for the deployment of geophones. If the survey is in a relatively undeveloped area, significant habitat disturbance may result. Many land crews now use helicopters instead of land vehicles in remote areas. Most countries require that seismic surveys are conducted according to environmental standards established by government regulation. Higher environmental standards have encouraged the development of lower impact seismic vehicles and acquisition methodologies. Similarly modern seismic processing techniques allow seismic lines to deviate around natural obstacles, or use pre-existing non-straight tracks and trails with less loss of data quality than would once have been the case. The more recent use of inertial navigation instruments for land survey instead of theodolites decreased the impact of seismic by allowing the winding of survey lines between trees.

marine surveys is the potential of seismic sources to disturb animal life, especially cetaceans such as whales, porpoises, and dolphins. Surveys involves towing an array of 15-45 pneumatic air guns below the ocean surface behind the survey vessel and emit sound pulses of a ñpredominantly low frequency (10ï 300 Hz), high intensity (215-250 dB). These animals have sensitive hearing, and some scientists[who?] believe the underwater sound waves created by air guns might disturb the animals or even damage their ears. Seismic surveying can damage the reproductive processes, auditory functions and other damaging effects to highly lucrative marine species (lobster, crab) and it poses potentially fatal effects to marine mammals.[citation needed] Seismic testing is not fully responsible for whales running ashore or becoming stranded, but there is evidence that it plays a major role.[citation needed] Studies of seismic effects on several whale species such as Gray, Bowhead, Blue, Humpback and Sperm whales indicated substantial effects in behavior, breathing, feeding and diving patterns.[citation needed] Dr. Bernd Würsig, a professor for marine biology at Texas A&M University in Galveston, Texas states that the Gray whale will avoid its regular migratory and feeding grounds by >30 km in areas of seismic testing. Similarly the breathing of gray whales was shown to be more rapid, indicating discomfort and panic in the whale. It is circumstantial evidence such as this that has led researchers to believe that avoidance and panic might be responsible for increased whale beachings although research is ongoing into these questions.

y both the E&P (exploration and production) sector and by environmental groups needs to be considered carefully in terms of impartiality as both may reference research or publish data that only promotes their own aims and goals. For example, the following quote comes from a position paper published by an E&P representative group which would appear to contradict the conclusions stated above. The quote from the executive summary states that:

"The sound produced during seismic surveys is comparable in magnitude to many naturally occurring and other man-made sound sources. Furthermore, the specific characteristics of seismic sounds and the operational procedures employed during seismic surveys are such that the resulting risks to marine mammals are expected to be exceptionally low. In fact, three decades of world-wide seismic surveying activity and a variety of research projects have shown no evidence which would suggest that sound from E&P seismic activities has resulted in any physical or auditory injury to any marine mammal species." [1]

Advantages

a. Reflection seismic observations are collected at small source-receiver offsets.

b. Reflection seismic methods can work irrespective of the speed at which motions propagate through the Earth varies with depth.

ons can be more readily interpreted in terms of complex geology.

d. Reflection seismic observations use the entire reflected wavefield.

e. The subsurface can be directly imaged from the acquired observations.

Disadvantages

f. Because many source and receiver locations must be used to produce meaningful images of the Earth's subsurface, reflection seismic observations can be expensive to acquire.

g. Reflection seismic processing can be very computer intensive, requiring sophisticated computer hardware and a relatively high-level of expertise. Thus, the processing of reflection seismic observations is relatively expensive.

h. Because of the overwhelming amount of data collected, the possible complications imposed by the propagation of ground motion through a complex earth, and the complications imposed by some of the necessary simplifications required by the data processing schemes, interpretations of the reflection seismic observations require more sophistication and knowledge of the process.

Advantages of Seismic Techniques

depth variations in a physically relevant parameter: seismic velocity.

b. Can produce detailed images of structural features present in the subsurface.

c. Can be used to delineate stratigraphic and, in some instances, depositional features.

d. Response to seismic wave propagation is dependent on rock density and a variety of physical (elastic) constants. Thus, any mechanism for changing these constants (porosity changes, permeability changes, compaction, etc.) can, in principle, be delineated via the seismic methods.

e. Direct detection of hydrocarbons, in some instances, is possible.

Disadvantage

a. Amount of data collected in a survey can rapidly become overwhelming.

b. Data is expensive to acquire and the logistics of data acquisition are more intense than other geophysical methods.

c. Data reduction and processing can be time consuming, require sophisticated computer hardware, and demand considerable expertise.

d. Equipment for the acquisition of seismic observations is, in general, more expensive than equipment required for the other geophysical surveys considered in this set of notes.

contaminants present at levels commonly seen in hazardous waste spills is not possible.

Unit 4 Electrical and Electromagnetic Methods

1.0 Introduction

2.0 Objectives

3.0 Main Body

The Electrical and Electromagnetic geophysical techniques represent some of the oldest means of exploring the Earth's interior. For example the SP method described below dates back to the 1830s when it was used in Cornwall, England by Robert Fox to find extensions of known copper deposits. Natural electrical currents in the Earth, referred to as telluric currents were first identified by Peter Barlow in 1847. The EM method was developed in the 1920s for the exploration of base-metal deposits.

of measurements of the effects of electrical current flow within the Earth. The phenomena that can be measured include current flow, electrical potential (voltages), and electromagnetic fields. A summary of the better-known electrical methods is given below.

DC Resistivity - This is an active method that employs measurements of electrical potential associated with subsurface electrical current flow generated by a DC, or slowly varying AC, source. Factors that affect the measured potential, and thus can be mapped using this method, include the presence and quality of pore fluids and clays. Our discussions will focus solely on this method.

Induced Polarization (IP) - This is an active method that is commonly done in conjunction with DC Resistivity. It employs measurements of the transient (short-term) variations in potential as the current is initially applied or removed from the ground, or alternatively the variation in the response as the AC frequency is changed. It has been observed that when a current is applied to the ground, the ground behaves much like a capacitor, storing some of the applied current as a charge that is dissipated upon removal of the current. In this process, both capacitative and electrochemical effects are responsible. IP is commonly used to detect concentrations of clay, and electrically conductive metallic mineral grains.

Self Potential (SP) - This is a passive method that employs measurements of naturally occurring electrical potentials commonly associated with shallow electrical conductors, such as sulfide ore bodies. Measurable electrical potentials have also been observed in and certain biologic processes. The only equipment needed for conducting an SP survey is a high-impedance voltmeter and some means of making good electrical contact to the ground.

Electromagnetic (EM) - This is an active method that employs measurements of a time-varying magnetic field generated by induction through current flow within the earth. In this technique, a time-varying magnetic field is generated at the surface of the earth that produces a time-varying electrical current in the earth through induction. A receiver is deployed that compares the magnetic field produced by the current-flow in the earth to that generated at the source. EM is used for locating conductive base-metal deposits, for locating buried pipes and cables, for the detection of unexploded ordnance, and for near-surface geophysical mapping.

Magnetotelluric (MT) - This is a passive method that employs measurements of naturally occurring electrical currents, telluric currents, generated by magnetic induction from electrical currents in the ionosphere. This method can be used to determine electrical properties of materials at relatively great depths (down to and including the mantle) inside the Earth. In this technique, a time variation in electrical potential is measured at a base station and at survey stations. Differences in the recorded signal are used to estimate subsurface distribution of electrical resistivity.

4.0 Summary

In this unit, the meaning of resource evaluation was discussed

6.0 References/Further Reading

Brown, Alistair R. (2004). Interpretation of three-dimensional seismic data (sixth ed. ed.). Society of Exploration Geophysicists and American Association of Petroleum Geologists. ISBN 0891813640.

Biondi, B. (2006). 3d Seismic Imaging: Three Dimensional Seismic Imaging. Society of Exploration Geophysicists. ISBN 0-07-011117-0.

Claerbout, Jon F. (1976). Fundamentals of geophysical data processing. McGraw-Hill.ISBN 1560801379.

Ikelle, Luc T. and Lasse Amundsen (2005). Introduction to Petroleum Seismology. Society of Exploration Geophysicists. ISBN 1-56080-129-8.

Scales, John (1997). Theory of seismic imaging. Golden, Colorado: Samizdat Press.

Yilmaz, Öz (2001). Seismic data analysis. Society of Exploration Geophysicists. ISBN 1-56080-094-1.

Chapman, C. H. (2004), Fundamentals of Seismic Wave Propagation (Cambridge University Press, Cambridge).

Unit 5 Solid Mechanics

0.0 Introduction

1.0 Objectives

2.0 Main Body

3.1 Solid mechanics

3.1.1 Introduction and Definition (After Wikipedia, URL)

Solid mechanics is defined as the application of the laws and principles of mechanics and hydraulics to engineering problems dealing with soil as an engineering material. Soil has many different meanings, depending on the field of study. To a geotechnical engineer, soil has a much broader meaning and can include not only agronomic material, but also broken-up fragments of rock, volcanic ash, alluvium, Aeolian sand, glacial material, and any other residual or transported product of rock weathering.

s the subject is concerned with the deformation and strength of bodies of soil. It deals with the mechanical properties of the soil materials and with the application of the knowledge of these properties to engineering problems. In particular it is concerned with the interaction of structures with their foundation material. This includes both conventional structures and also structures such as earth dams, embankments and roads which are their-selves made of soil.

Solid mechanics is the branch of mechanics, physics, and mathematics that concerns the behavior of solid matter under external actions (e.g., external forces, temperature changes, applied displacements, etc.). It is part of a broader study known as continuum mechanics. One of the most common practical applications of solid mechanics is the Euler-Bernoulli beam equation. Solid mechanics extensively uses tensors to describe stresses, strains, and the relationship between them.

3.0 Summary

4.0 Conclusion

5.0 References/Further Reading

Unit 6 Fluid dynamics

1.0 Introduction

2.0 Objectives

3.0 Main Body

In physics, fluid dynamics is a sub-discipline of fluid mechanics that deals with fluid flowð the natural science of fluids (liquids and gases) in motion. It has several subdisciplines itself, including aerodynamics (the study of air and other gases in motion) and hydrodynamics (the study of liquids in motion). In the geomorphology, we are particularly concerned with hydrodynamics. Fluid dynamics has a wide range of applications, including determining the mass flow rate, predicting weather patterns, etc..

Fluid dynamics offers a systematic structureð which underlies these practical disciplinesð that embraces empirical and semi-empirical laws derived from flow measurement and used to solve practical problems. The solution to a fluid dynamics problem typically involves calculating various properties of the fluid, such as velocity, pressure, density, and temperature, as functions of space and time.

something different than it does today. Before the twentieth century, hydrodynamics was synonymous with fluid dynamics. This is still reflected in names of some fluid dynamics topics, like magnetohydrodynamics and hydrodynamic stabilityð both also applicable in, as well as being applied to, gases.[1]

Unit 7 Landscape evolution modeling

1.0 Introduction

2.0 Objectives

3.0 Main Body

A landscape evolution model is a physically based numerical model that simulates changing terrain over the course of time. This can be due to glacial erosion and deposition; erosion, sediment transport, and deposition in fluvial systems such as rivers; regolith production; the movement of material on hillslopes; more intermittent events such as rockfalls, debris flows, landslides, and other surface processes. This can also be due to surface uplift and/or subsidence. A typical landscape evolution model takes many of these factors into account.

ed primarily in the field of geomorphology. As they improve, they are beginning to be consulted by land managers to aid in decision making.

The earliest of these models were developed in the 1970s. In these models, water was run across a mesh, and cell elevations were changed in response to calculated erosion.

4.0 Summary

5.0 Conclusion

6.0 References/Further Reading

From Wikipedia, the free encyclopedia

Coulthard, T. J. (2001). "Landscape evolution models: a software review". Hydrological Processes 15: 165. doi:10.1002/hyp.426.

MODULE 5 [RESOURCE PROCESSES]