Appendices

Appendix (A)

Mini- Cement Plant In Ethiopia

Market Study

1. Past Supply

Cement is, by-far, the most important construction material manufactured in Ethiopia , accounting for 85% of the value in the non-metallic manufacturing sector. All local cement is produced in the three factories, Mugher, Mesebo and Dire Dawa. The combined capacity of these three factories is about 1.3million tonnes per annum, but the largest part of the supply comes from Mughe rand Mesebo (more than 95%) .In addition to domestic production, the country also imports some amount of cement from European and Asian countries. The imports are, however, mostly of such types that are required for special construction purposes (aluminous cements, hydraulic cement, etc).The apparent consumption data of cement, comprising of domestic production and imports(1994-2003), is shown inTable.2.4(.htt://www.ethioembassy.org.uk/trade-and investment/)

Table 1 Apparent consumption of cement (tones)

Year	Production per (tons)	Import per(tons)	Total
1994	464396	95	464491
1995	609260	388	609648
1996	672483	115	672598
1997	774666	2283	776949
1998	782686	7712	790398
1999	766925	162	767087
2000	815632	224	815856
2001	819047	194	819241
2002	919169	388	919557
2003	1200000	518	1200518

Table 1 shows that both local production and import of cement in Ethiopia is characterized by a growth trend. Over the 10 years period covered by the data set (1994-2003),local production was growing at an annual average growth rate of 11%.Except for two exceptional years 1997&1998),imports constitute less than1% of the total supply. Even in those exceptional years, the maximum proportion of imports did not exceed 10%. Therefore, one can conclude that the impact of imports on the domestic cement market is not significant. Following increased construction activity all over the country, demand for cement is currently soaring at an increase in grate. As the local producers are only three large scale factories, sudden shortages are created when one of them interrupts production for technical or other reasons. As consequence, prices shoot up ward and many construction activities face problems owing to supply shortage. It is also easy to infer from the data in Table2.4 that, presently, the factories are working at nearly 100% of their capacity. Hence ,unless new capacity is created in time as ever short fall

of supply is going to materialize in the very near future, there by negatively impacting on construction activity in particular and the country's development in general. Assuming the present level of supply, which is about 1.2million tones, satisfies only 80 % Of the demand. The present effective demand for cement is estimated at 1.5 million tones.

2. Projected Demand

The future demand for cement, like many other construction materials is function of anumber of inter related variables. Considering all the above factors and the growth trend in supply observed from the historical data, future demand is forecasted to grow at arate of 10%, annually. Accordingly, projected demand for cement ranges from1.6million tons in the year 2005 to 5.7 million tons by the year 2018 (seeTable2.5).

Table 2 Projected demand for cement (2004-2018)

Year	**Projected Demand (Million Tones)**	**Existing Capacity (Million Tones)**	**Demand Gap (Million Tones)**
2004	1.5	1.3	0.2
2005	1.65	“ “ “	0.35
2006	1.8	” “ “ “ “ “ “ “ “ “ “	0.5
2007	2.0		0.7
2008	2.2		0.9
2009	2.4		1.1
2010	2.6		1.3
2011	2.9		1.6

Plant Capacity

According to the market studied ,the demand gap for cement product begins with 200,000 tonnes for the year 2004, and will reach to 1,300,000 tonnes by the year 2010. Mini-Cement Plants (MCPs) can be established with varying production capacities. The technology of VSK-based cement production is available with capacities of 20, 30 , 50 ,100, 200 and max 300 tonnes per day for MCPs. Although the demand gap of cement in the region is, by-far, lower than that of the average national figure, it is proposed that an MCP of 200 tonnes per day capacity shall be established. Such a plant will operate 24 hours a day, and for 300 days a year, producing a total of 60,000 tonnes of cement.

Production Programmer

The anticipated mini-cement plant will start its operation at 75 % in the first year, 85 % in the second year ,and at 100 % in the third year and then after. The detail is shown in Table 2.6 below.

Table 3 Production programmer

Year	1	2	3-10
Capacity utilization (%)	75	85	100
Cement (Tones)	45,000	51,000	60,000

Materials and inputs

The details of raw materials requirement for cement production is shown in Table 2.

Table 4 Raw materials requirement and cost ($)

Sr. No.	Description	Qty. (Tones)	Unit Cost	Total Cost
1	Limestone, (72-76)%	61,00	2.381	145238.1
2	Clay, (6-10)%	10,00	0.047619	476.19
3	Sandstone, (8-12)%	6,500	3.095	20119.04
4	Pumice, (2-4)%	3,210	3.057142	9813.42857
5	Gypsum, (4-5)%	2,400	5.7142857	13714.28571
	GrandTotal Cost	-	-	189361.0443 $

1. AUXILIARYMATERIALS

Three-ply paper bag is required for packing cement. Addis Ababa Cement Plant is engaged in the production of this bag, and procurement can be processed locally. A total of 1.2 million sacks of 50kg each is required. The annual expenditure on paper bags is estimated at 285714.2857$.

2. UTILITIES

VSKs of MCPs do require energy in the range of 1000-1100 kcal of heat per kg of clinker. Similarly, consumption of electrical power in MCPs is in the order of 120 units per ton of cement as compared to large cement plants which lies in the range of 100-110 units per ton. Consequently, electricity and fuel oil are highly required. Water is also essential for human consumption and for production process. Annual requirement of utilities is shown in Table 2.8.

Table 5 Annual utilities requirement and cost

Sr.	Description	Qty	Cost ('000 $)
1	Electricity, kWh	7,200,000	162.5143
2	Water, m^3	50,000	3.57143
3	Fuel oil, litres	6,200,000	738.1
	Total Cost		904.181

Machinery and Equipment

The list of machinery and equipment required is provided in Table 2.9.The total investment cost of these machinery and equipment is estimated at 3809523.81 $, of which 3571428.571 $ is required in foreign currency.

Table 6 Machinery and equipment requirement and cost

Sr. No.	Description	Qty.	Cost, (000 $)		
			LC	FC	TC
I	**Preparation Section**				
1	Drilling Rig.	1			
2	Loaders	2			
3	Crusher	1			
4	Bucket Elevator	As req.			
5	Silos	As req.			
6	Grinding Mill	1			
7	Dust collector	As req.			
8	Pumps	"			
9	Roller mill	1			
10	Dump trucks	2			
II	**Burning Section**				
1	Fan	As req.			
2	Dust collector	set			
3	Preheater	1 set			
4	Vertical shaft kiln	1 set			
5	Grate cooler	1 set			
6	Bucket elevator	As req.			
7	Storage tanks	1			
III	**Clinker Grinding**				
1	Silos	As req.			
2	Grinding mill	1			
3	Air separator	As req.			
4	Dust collector	As req.			
5	Bucket elevator	As req.			
IV	**Auxiliaries**				
1	Power supply system (inc. dieselgen)	set	238095.238$	3571428.571$	
2	Fuel storage tanks	2 sets			
3	Water supply unit	2 sets			
4	Compressed air system	1 set			
5	Workshops	As req.			
	Grand Total		**238.1**	**3571.43**	**3809.523**

Land, Building and Civil works

The site area of 10,000 m^2 is required for the plant under consideration. Of this, an area of about 1,500 m^2 will be covered by production buildings, including auxiliary buildings. At the rate of 95.24 $ per m^2,the investment cost for buildings will be 142857.143 $. The cost of l and leasing, at the rate of 0.09524 $ per $m^2$and for 70 years land holding, will b e66666.667 $. Thus ,the total cost of land, building and civil works assuming that the total land lease cost will be paid in advances 209523.81$.

Manpower and training requirement

The envisaged mini-cement plant requires 71 employees. The man power requirement and corresponding labor cost including employees 'benefits is shown in Table 2.10.

Table 7 Manpower requirement and annual labor cost

Sr. No.	Description	Req. No.	Salary, $	
			Monthly	Annual
	A. Administration			
1	General Manager	1	95.24	1142.9
2	Secretary	1	24	285.72
3	Administrative&Finance	1	57.143	685.7144
4	Accountant	1	35.714	428.6
5	Clerks	3	16.67	600
6	Storekeeper	1	28.572	342.9
7	Personnel Officer	1	35.7143	428.6
8	Purchaser	1	35.7143	428.6
9	General Services	10	16.67	2000
10	Guards	6	12	857.143
	Sub–total	26		7200.1774
	B. Production & Technical			
1	Production	1	85.7143	21600
2	Supervisors	3	57.143	2057.14
3	Instrumentation Engineer	1	57.143	685.714
4	Mechanical Engineer	1	57.143	685.7143
5	Electrical Engineer	1	57.143	685.7143
6	Foreman	3	42.86	73.47
7	Technicians (shift)	6	28.56	2057.14
8	Operators(skilled)	15	28.56	5142.86
9	Unskilled Workers	10	9.524	1142.86
10	Chemist	1	47.62	571.43
11	LaboratoryTechnicians	3	23.81	857.143
	Sub–total	45		16457.143
	Total	71		23657.143
	Employees' Benefit			5914.3
	GrandTotal			29571.43

Financial analysis

The financial analysis of the Mini-Cement Plant project is based on the data presented in the previous chapters and the following assumptions:-

Construction period	1 years
Source of finance	30 % equity
	70 % loan
Tax holidays	3 years
Bank interest	7.5 %
Discounted cashflow	8.5 %
Repair and maintenance	3 % of the total plant and machinery
Accounts receivable	30 days
Raw material, local	30 days
Raw materials, import	90 days
Work in progress	days
Finished products	30 days
Cash in hand	5 days
Accounts payable	30 days

1. Total initial investment cost

The total initial investment cost of the project including working capital is estimated at 4566190.5 $, of which 88 per cent will be required in foreign currency. The major break down of the total initial investment cost is shown in Table 2.11

Table 9 Initial investment cost

Sr.	Cost Items	Total(000 $)
1	Land lease value	66.67
2.	Building and Civil Work	142.86
3.	Plant Machinery and Equipment	3809.524
4.	Office Furniture and Equipment	3.572
5.	Vehicle	17.857
6.	Pre-production Expenditure	252.6
7	Working Capital	273.38
	Total Investment cost	4566.43
	Foreign share	88.39%

2. Production cost

The annual production cost at full operation capacity is estimated at 1852380.96 $ (see Table2.12). The material and utility cost accounts for 65.1 per cent while repair and maintenance take 1.3 percent of the production cost.

Table 10 Annual production cost at full capacity ('000 $)

Items	Cos	%
Raw Material andInputs	189.333	10.88
Utilities	904.143	51.95
Maintenanceand repair	23.81	1.37
Labour direct	16.457	0.95
Factoryoverheads	0.9524	0.05
Administration Cost	7.2	0.41
Total Operating Costs	1252.57	71.97
Depreciation	392.79	22.57
Cost of Finance	205.64	11.82
Total Production Cost	1740.35	100.0

3. Profitability

According to the projected income statement,the project will start generating profit in the 1st year of operation. Important ratios such as profit to total sales ,net profit to equity (Return one quity) and net profit plus interest on total investment (returnontotalinvestment) show an increasing trend during the lifetime of the project.The income statement and the other indicators of profitability show that the project is viable.

4. Break-even Analysis

The break-even point of the project including cost of finance when it starts to operates at full capacity (year 3) is estimated by using income tatement projection.

$$BE = \frac{\text{Fixed Cost}}{\text{Sales} - \text{Variable cost}} = 63\%$$

5. Pay-Back Period

The investment cost and income statement projection are used to project the pay-back period. The project's initial investment will be fully recovered within 6years.

6. Internal Rate of Return and Net Present Value

Based on the cash flow statement, the calculated IRR of the project is 16% and the net present value at 8.5% discount rate is 1510476.2 $.

7. Economic benefits

The project can create employment for 71 persons. In addition to supply of the domestic needs, the project will generate 180952.4 $ per annum in terms of tax revenue when it starts to operate at full capacity. Moreover, the Regional Government can collect employment, income tax and sales tax revenue. The establishment of such factory will have a foreign exchange saving effect to the country by substituting the current imports.

Appendix (B)

Geophysical Survey in south Darfur

Preface:

This section generally show the marble and limestone in area of study use Remote sensing and digital image to Evaluate the deposit. At national level the were many regions had a great potentials for industries related to cement production, many studies conducted covering the most aspects regarding the cement production among which is the geophysical and geochemical study with the aid of remote Sensing and Digital image by Dr. Khalid Mustafa Kheiralla and others } which conducted in south Darfor Reigon at JURIF area , the findings of the study show that the area are promising , the raw materials are available with a quality and quantities encouraging the establishment of industries related to cement production at the area , the study conducted in the 2012**.**The scope of the current study is based on that findings with techno-Economical study completing the work of the mentioned team and to meet the objectives of the study mentioned before , in this chapter a details of the of the geophysical survey and geo chemical analysis to introduce its findings to the feasibility study**.[3]**

The marble in South Darfur

Marbles are common all over northern part of Nyala town, South Darfur and occur at patches form as a member of the basement complex rocks. The project area located in the South Darfur state, and situated in the northern part of the state, bounded by longitudes 24°57'36.89" and 25°03'03.36" East and latitudes 12°33'04.80" and 12°29'45.36" North. It has an area of approximately 45 square kilometers. The area characterized by flat topography, low elevated ridges and drainage pattern characterize the most of the area especially in southern part of the area.The study is required to be conducted estimate of reserve for marble using geological mapping for the manufacturing of cement. This quarry lies within a cluster of maximum 100 km north Nyala town and 10 km north Duma village. The quarry site is crossed by Nyala-El Fashir road and lies within a terrain of basement rocks covered by thin layers of wdai deposits, sandy and sandy clayey layers.This work represents the detailed geological/structural mapping for the Nyala concession area, which will be followed by later more in depth investigation (geophysical and geochemical). This is work will be based on the geological/ structural mapping using field work, Landsat image processing and GIS means in all activities. Nevertheless, previous geological and geochemical works and previous data have been taken in consideration in assessments plans beside a field ground truthing work**.[3]**

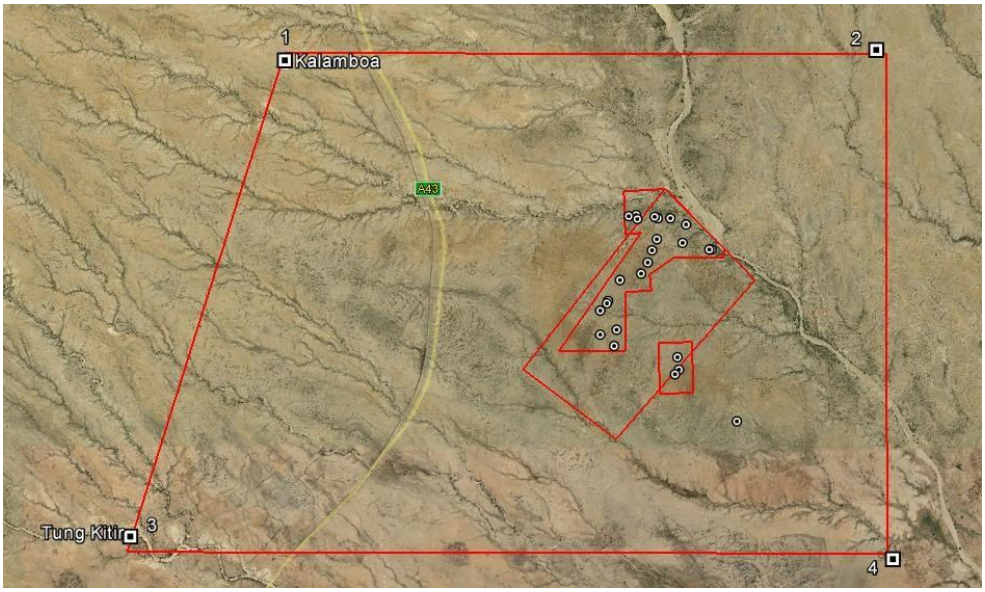


Fig 1. Location of the study area

The study is based mainly on geological mapping using remotely sensed data and on digital image processing, visual interpretation and spectral and spatial analysis in GIS framework with fieldwork or ground truth checking. The main objective of the study is to create a geological map and delineate various structural aspects of the area in addition to pilot prospecting work to pin point the marble deposits which could be related to estimate of reserve for marble.The multi-spectral of Landsat 7 beside the semi hyper spectral data of ASTER sensor beside the elevation data of SRTM (Shuttle Radar Topography Mission) are the main source of this study beside previous geological maps and reports. The geological mapping has been carried in a detail survey and it is adequate for the collected rock sampling, lithological discrimination of major rock units, identify of different assemblages, different grade and facies. The main structural elements as well as various deformational phases have been documented in this mapping.

Remote sensing investigation

Remote sensing was performed using the multispectral data of Landsat ETM+7, smi- heper spectral ASTER data and digital elevation model obtained from SRTM and ASTER mission.

The optical multispectral data of Landsat have been utilized worldwide in geological application since the last century for the interpretation of the Landsat imagery, where ASTER data (launch in 1999) have used in geological application, which paved road to the space-borne hyper spectral sensor

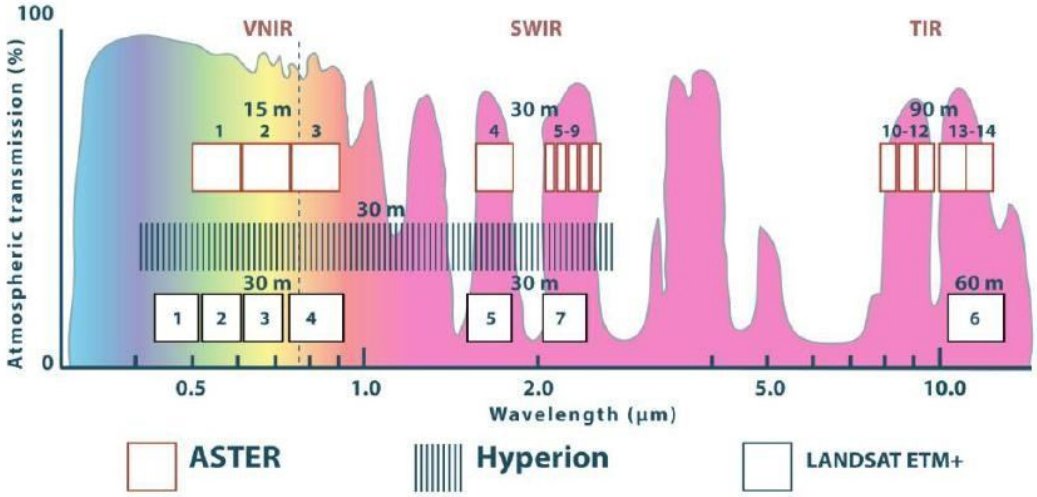


Fig. 2. The mineral Under Land Sat, and ASTER

Band-passes of the Landsat ETM, ASTER and Hyperin sensor in relation to diagnostic spectral features of several hydrothermal alteration minerals. Note: the spectral absorption in the Blue spectrum for iron oxide minerals and at around 2.3um for the clay minerals. These diagnostic spectral signatures are used to detect the alteration zones and the associated sulphide minerals Landsat series are one of the most treasured

sources for earth observation system. The Landsat have been utilized in different environmental and natural resources studies in different disciplines. Satellite images have been utilizedto digitize the lineaments and drainage of the under consideration. Results are more or less conformable with the ones extracted from the DEM (Digital elevation Model) image of the SRTM data. The digitized lineaments from satellite imagery have more than one trend; major and minor trends can be structurally analyzed after field measurements (Fig 2).

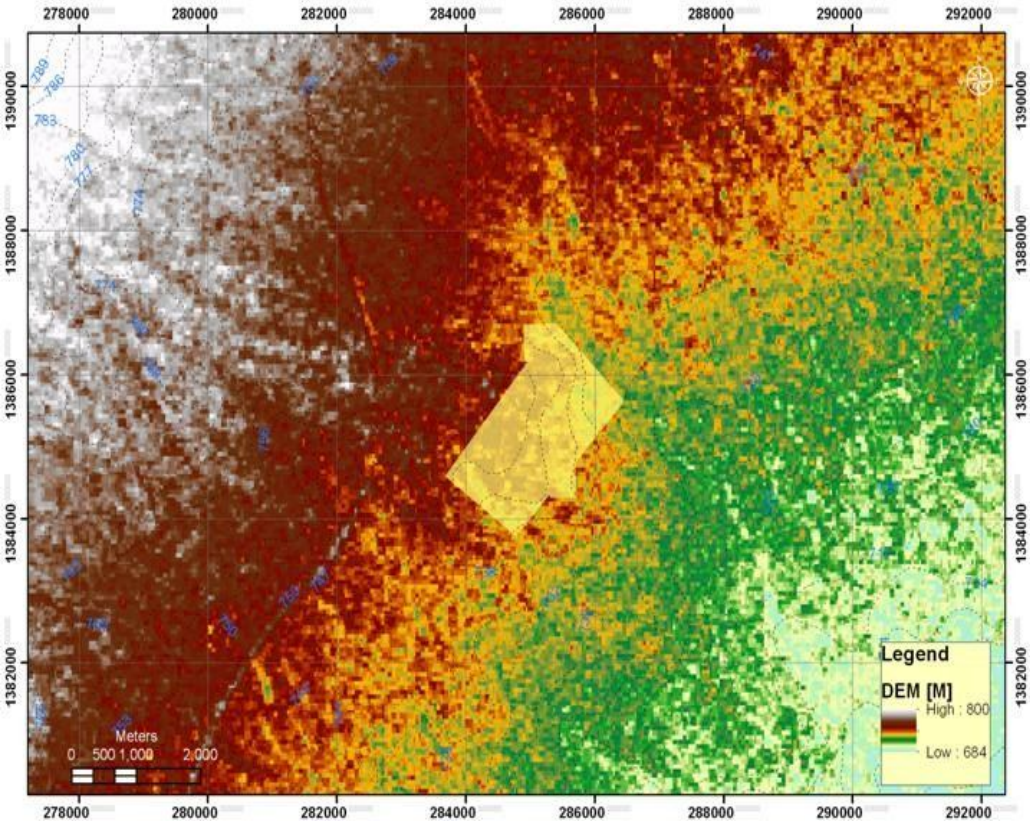


Fig. 3. Topography map expressed by theDEM image and contour line.

Some topographic analysis was performed in this study. The present analysis focused predominantly on understanding the drainage patterns of the region and their connection to the topography as this will determine crucially the planning of future geochemical and

geophysical surveys. The results of the topographic analysis are shown in Figure (3).

The surface elevation range between 684 and 800 m, whereas the general topography slopes towards the southeast. The region of highest surface elevation is located in the north western part of the area. Topographic features like mountain ridges or incised valleys are characterized in the DEM image by a strong brightness contrast that is proportional to the topographic gradient and related to the direction of strike of the feature relative to the direction of illumination. In all presented maps the topography is illuminated by an azimuth angle of 300° and an altitude angle of 30°.The drainage system revealed more straight parallel drainage lines, which are controlled by the general structure manifested in the fault system in upstream these wadis exhibit feather-like drainage system (Figure 4).

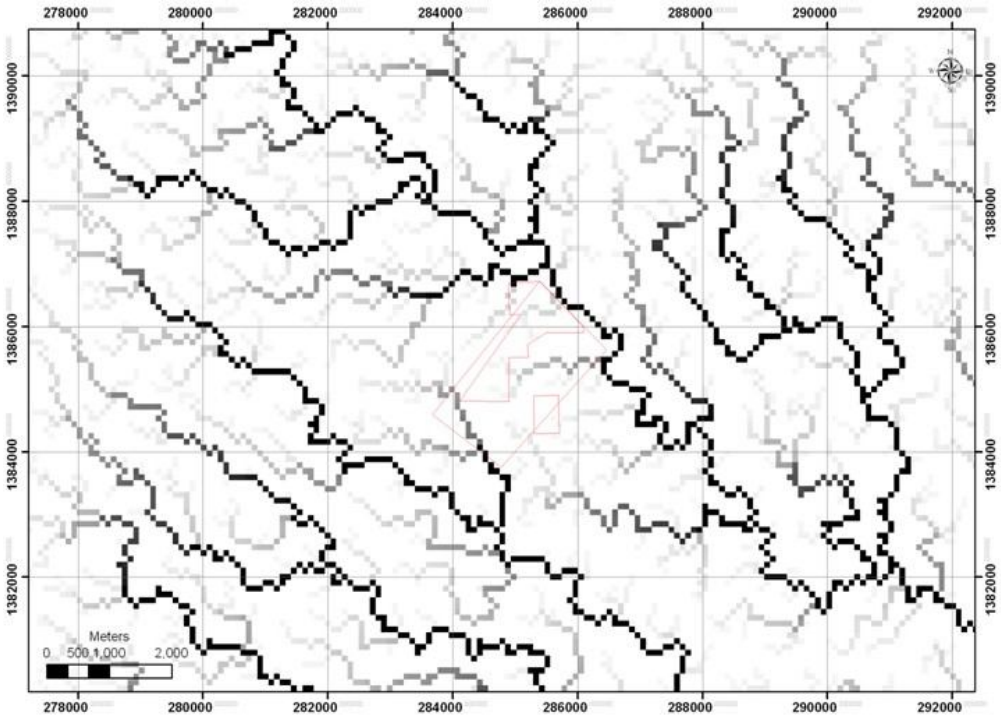


Fig.4. Drainage and sub basin map of the study area

The drainage system and the watersheds of the region are extracted from the SRTM data. Individual channels are determined by applying Arc Hydro flow routing algorithm (and by the calculation of the upstream Drain age area.

Evaluation of the marble deposits

1. Geological and Structural mapping

The products of the digital image processing and the field ground truthing work beside the previous map implement the geological interpretation to perform the geological map and other major structural elements in the area (Fig.5).

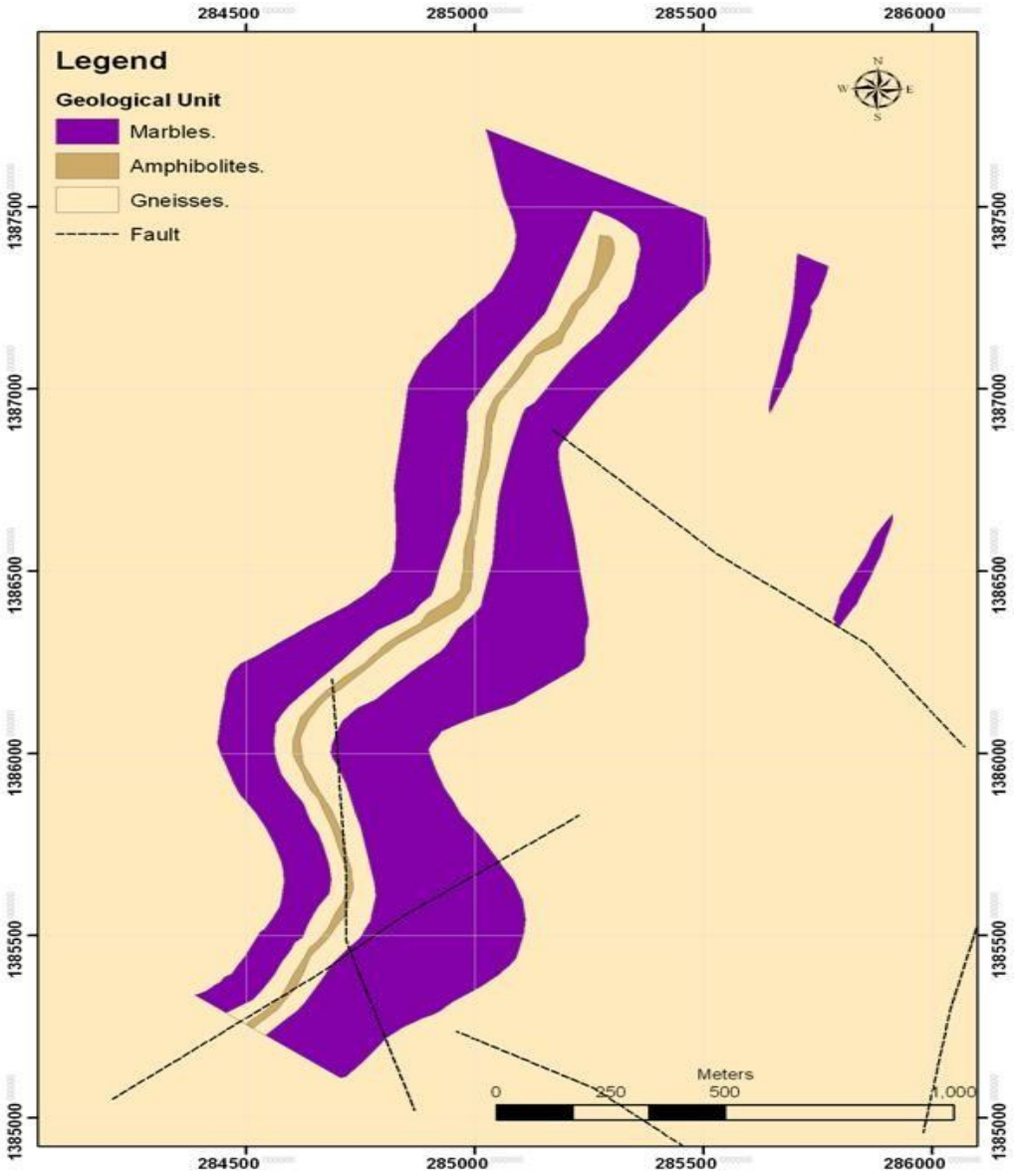


Fig.5. Geological map of the study area

And 4 thin-sections have been studied under the microscope to determine mineral composition, mineral assemblages, textures, and structures, degree of alteration, origin and grade of metamorphism. The slides have been partly prepared at the Laboratory of School of Applied Earth Science of Al Née lain University. The produced geological map (Fig.5) summarized the general litho logical and structural elements in the study area. The area is mainly covered by the Basement Complex rocks and the

general geological units are summarized from the oldest to the youngest as follows:

I. High-grade granitic gneisses

II. Basic Meta volcanic

III. Marbles and cal-silicate rocks

IV. Alluvial wadi deposits

Generally, the area is covered by basement rocks of Pre-Cambrian – Cambrian age consisting of granitic gneisses and less dominantly of low grade meta-volcano sedimentary assemblages (Fig.5).The meta-volcano sedimentary assemblages (Amphibolites) rocks are generally dense, massive or foliated and banded. In hand specimen the amphibolies are dark green in color, coarse-grained and are composed mainly of ferromagnesian mafic minerals and plagioclases. Hornfelsic variety with garnet porphyroblasts are uncommon especially adjacent to the igneous batholiths.Under the microscope the dominant amphibolite units consist mainly of felsic and mafic phases. The felsic phases are dominated by plagioclase ranging in composition from andesine to labrodarite (fig3.7).

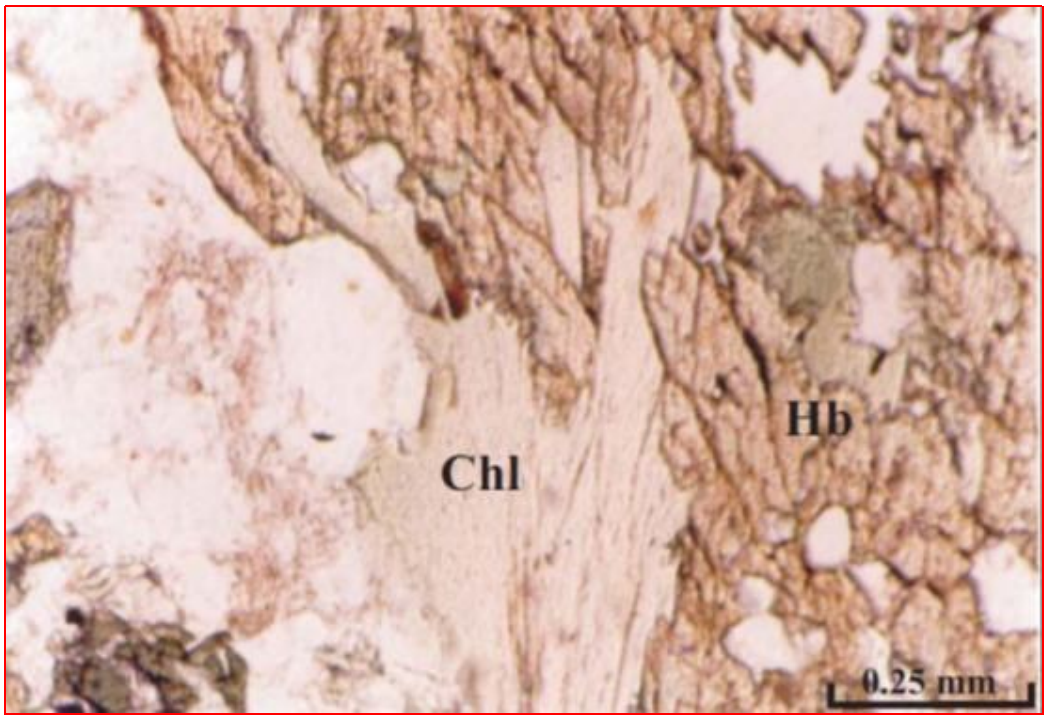


Fig 6.Chlorite in the rock

Photomicrograph amphibolites rock showing formation of chlorite after Hornblende in sinisterly regime Marbles form low-lying surface outcrops (fig3.8 and 3.9) and large layers with variable thickness, extending few kilometers along the strike NE-SW (Fig3-6). They occur as bands and lenses trending between 15° to 30° and dipping 40° to the NW. They are generally medium-to coarse-grained in texture. The general surface is massive with only an observed cleavage. The marbles are white in color, sometimes grey. They are easily identifiable in satellite images characterized by blue color in Landsat image of bands 7, 4 and 1 (RGB color composite) The marble is commonly medium to coarse- grained and recrystallized with calcite grains ranging from 1 to 3 mm in size. Calcite represents the major mineral composition of the pure marble (more than 90% of the whole rock). In the thin section show little

impurities in the marbles mainly of quartz grains, which indicate slight silicification (fig. 9)

From field observations, these rocks are show many phases of deformation as folding and refolding. The sheared marble zone has boudinage structure. The marbles and calc- silicate rocks make a large anticlinal fold with foliated granitic gneisses in the core of the anticline (fig. 10, 6&Fig. 11). The fold axis trends NW-SE. The intensity of deformation in calc-silicate rocks and marbles is the same as in the amphibolite and granitic gneisses (fig 12).

Fig 7.Outcrops of marble extending NE-SW along the strike

Fig8. Outcrops of marble, show dipping45° NE

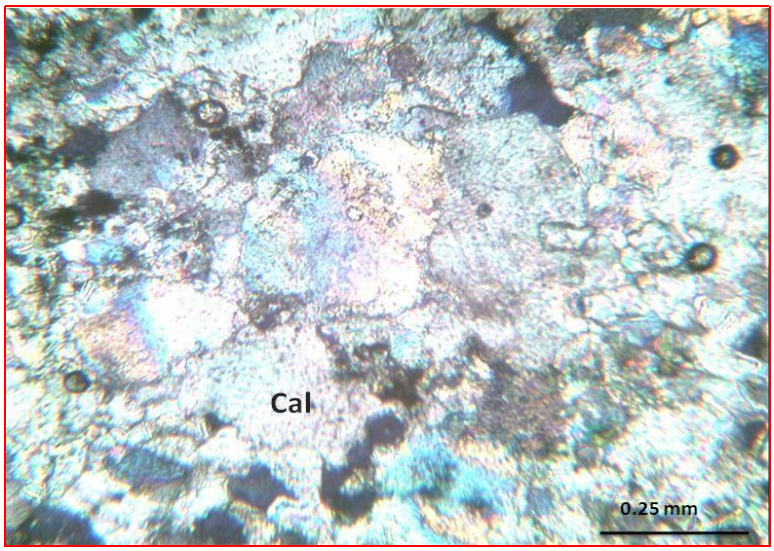


Fig .9. Photomicrograph marble rock showing formation of calcite

Fig 10. Tight isoclinal Folding and refolding

Fig 11. Isoclinal recombant fold verging to the south in foliated amphibolites

Fig 12 Sheared granitic gneisses showing structure trending NW-SE.

2. Geophysical survey

Fifteen horizontal electrical profiling (hep) trending in the nw-se perpendicular to the marble deposits was carried out (fig3-14). these profiles give an idea about the lateral variation in the resistivity of the ground, which may be due to lateral lithological or structures differences the locations of all hep have been fixed by gps. the profiles are assigned serial numbers going form. hep1 to hep 15 (table3.1 &fig3.14).

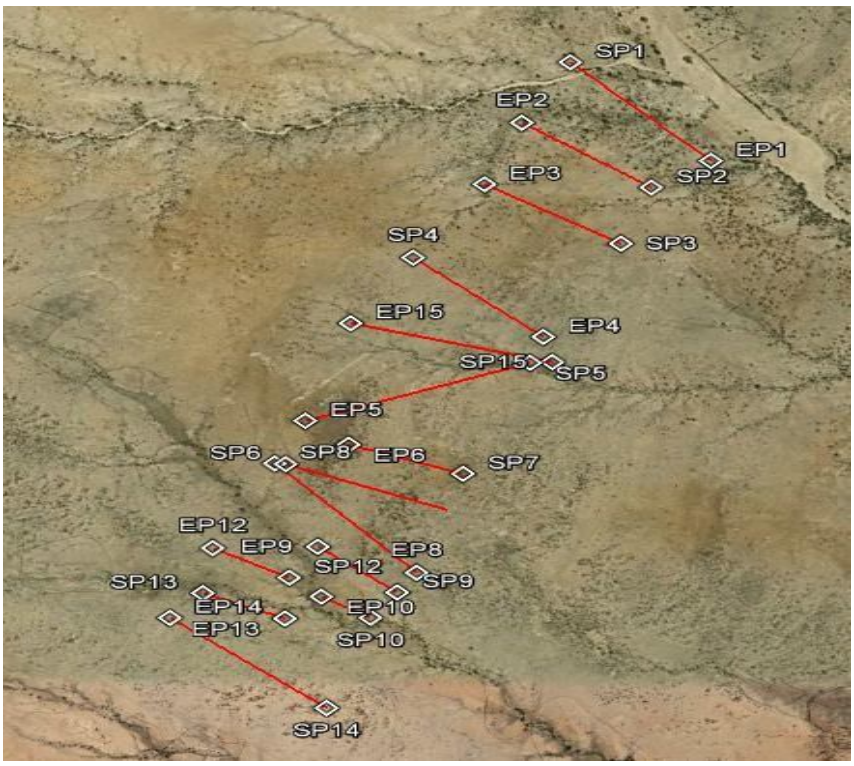


Fig 13. Location of the Horizontal Profiling (HP)

the hep measurements have been conducted using an abem sas-1000 terrameter (sweden). the instrument is relatively powerful and has high sensitivity. the profiles were performed adopting a wenner electrode arrangement with half separation between current electrodes 50 m, half separation between potential electrodes 25m with this separation the

depth of investigation is between 20 to 25m.the obtained resistivity data were plotted in a millimeter graph of apparent resistivity versus station intervals to show anomalous areas

Table 1.Cordinates (HEP) Location

W-	Y-	Start	W-easting	Y-	End
285215	1386733	SP1	285688	1386238	EP1
285485	1386107	SP2	285049	1386433	EP2
285380	1385828	SP3	284920	1386127	EP3
284676	1385763	SP4	285114	1385366	EP4
285068	1385237	SP5	284305	1384954	EP5
284237	1384739	SP6	284451	1384835	EP6
284200	1384743	SP8	284676	1384195	EP8
284609	1384097	SP9	284342	1384327	EP9
284518	1383972	SP1	284352	1384078	EP10
284244	1384174	SP1	283986	1384323	EP11
283951	1384099	SP1	284228	1383971	EP12
284366	1383524	SP1	283838	1383977	EP13
285143	1385240	SP1	284462	1385439	EP14

Drilling

Five scattered boreholes were drilled on the concession area, Figure 14 and (Table 2). is showing the drilled in area of study, Four of these boreholes are more than 2m and one 1.5m deep. The total drilled depth is 10.3m. Core recovery (CR %) and rock quality designation (RQD %) have been calculated, their average values are 80 and 51 respectively.

Figure 14. Drilled in area of study (for testing materials)

Table 2 Location of drilled boreholes in concession area

X-easting	Y-	Elevation	BH No	Depth	Remarks
285455.00	1386578.0	7	BH1	2.7	Marble Continuous
285206.00	1385916.0 0	7 4	BH2	2.0 7	Marble Continuous and
285201.00	1385329.0	7	BH3	1.	Marble Continuous
284756.00	1384794.0	7	BH4	2	Marble Continuous
284507.00	1384187.0	7	BH5	2	Marble shows after

Geochemical analysis:

The chemical analysis determines percentage of the main oxides, every one meter depth is taken as one sample and several samples were taken from the exposure rock. 20 samples were prepared and chemically analyzed; all the samples results within the required percentage except samples number GS1, GS3, GS10, GS11, GS13, GS18 and GS19 give less CaO and high MgO (Table 3-3). The physical properties of Crushing Value

(CV), Uniaxial Compressive Strength (UCS) and Specific Gravity (SG) have been tested for selected sample, their average values are 25.5 %, 733 kg/cm^2 and 2.7 g/cm^3 respectively.

Table. 3. Result of chemical analysis of the marble in jourf

X-	Y-	Sample	CaO	MgO	X-	Y-	Sample	CaO	MgO
284847	1385651	GS1	25.31	17.04	285644	1386306	GS11	22.06	14.62
284703	1385403	GS2	44.48	2.21	285600	1386088	GBD	43.43	0.23
284689	1385376	GS3	28.55	16.2	285946	1386006	GS12	31.87	10.34
284609	1385290	GS4	39.65	2.89	285234	1386001	GS13	28.62	7.56
284804	1385062	GS5	49.72	14.49	285182	1385858	GS14	48.21	0.8
284772	1384868	GS6	40.04	0.77	285101	1385725	GS15	45.87	1.21
286236	1383962	GS7	44.27	0.63	285292	1386133	GS16	46.85	0.97
285061	1386374	GS8	50.11	1	285498	1384527	GS17	27.15	13.82
285306	1386382	GS9	30.43	11.53	285529	1384730	GS18	20.52	13.89
285457	1386381	GS10	24.14	14.62	285546	1384582	GS19	19.92	15.06

-In Darfur region there are many different places for raw material uses in Cement Manufacturing such as marble rock , buozolana and limestone ,and the Figure 3.16 show the locations of raw material in Darfur region like (Miedob volcanic, Tagabo volcanic, Jebel marra volcanic,Saraf omra kaolin, Rahd abiad kaolin, Jourf marbel ,El-fashir ,Genina ,Zalegi ,Nyala ,Dein).This all at show in Figuer blow

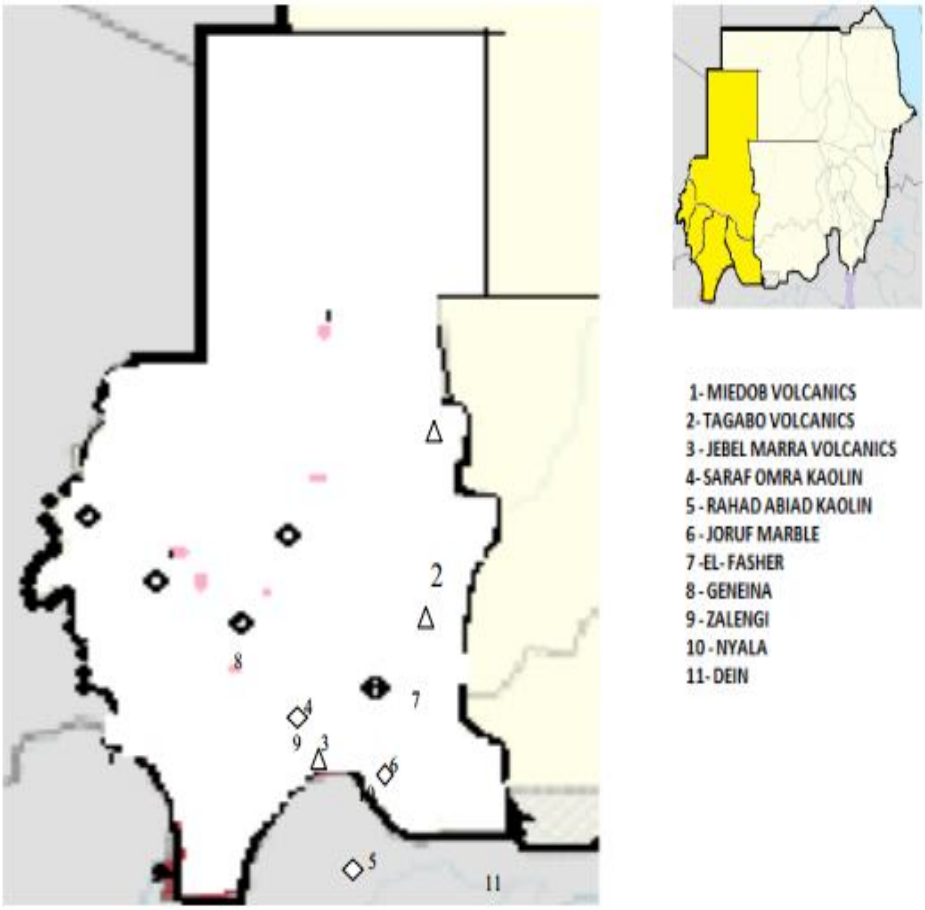
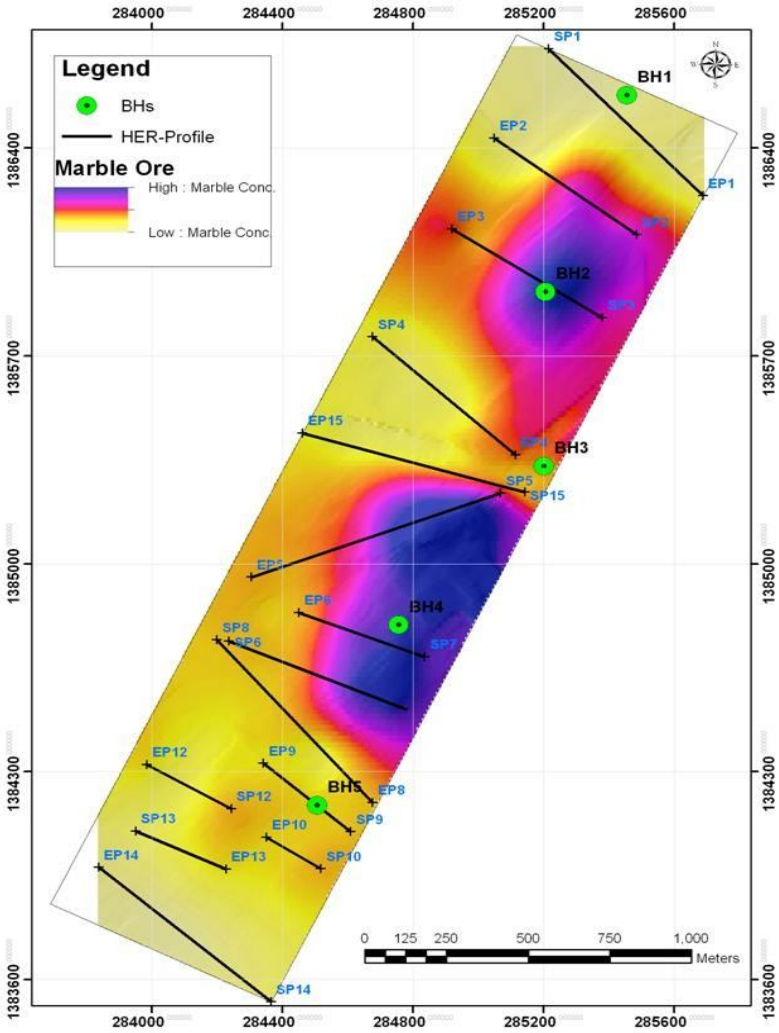


Figure 15.Location of the raw materials of Cement in Darfur

3D Geo-modeling

3D geo-model has been conducted to create a volumetric for estimate of reserve using integrates multidisciplinary geo-model characterization Area of marble deposits have also been constructed for layer in fixed depth (12m) below ground surface as shown in (Fig.14). The apparent resistivity estimated by simple kriging with boreholes data, the resistivity range is from high to low marble concentration.



Figuer.16. the marble deposits in jourf area

This figure show the Area of marble deposits estimated by simple Kriging and well marker in fixed depth below ground surface, the violet to blue color is the target potential marble zones.

Reserve estimation

The estimate of reserve is based on:

i. Remote sensing investigation (Fig. 3)

ii Geological and Structure mapping(fig14)

iii. Geophysical survey

iv.Drilling (Table 3)

v.Geochemical analysis (Table 4)

vi.3D volume model (Fig.14)

Estimation of the reserve (ER) is obtained from the total area (A) of the deposit multiplied by the average depth (Z) of the marble obtained from boreholes

$$ER = A \times Z \quad [m^3]$$

$$ER = A \times Z \times D \quad [tons]$$

The total area is 1265000m^2, and average depth is 12m. The density (D) of marble is 2.7 g/cm^3, so the reserve estimated is:

*1265000*12 = 15180000m^3*

*5180000*2.7= 40986000 tons*

Result of marble deposits in the area of study:

According to the stander values of the main oxides for cement industry the chemical analysis shows 80% of the analyzed samples of marble deposits in this area is suitable for cement industry based on CaO, MgO and SiO_2.

Limestone Deposits in Southern Darfur:

Definition of limestone (Calcium carbonates)

Calcium carbonate is a chemical compound with the formula $CaCO_3$. It is a common substance found in rocks in all parts of the world, and is the

main component of shells of marine organisms, snails, coal balls, pearls, and eggshells.

Formula: $CaCO_3$

Molar mass: 100.0869 g/mol

Density: 2.71 g/cm³

IUPAC ID: Calcium carbonate

Melting
point:
25°.
Basic
Cement
Source

Coordinates the area of study:

The model presents a study about the potential of spectral unmixing of Hyperspectral satellite images data for targeting and quantification of mineral content in limestone rich areas in Southern Darfur/Sudan bounding according to coordinates blow **[4]**

A)-N 12°33'2.12”/ E 24°59'0.89"E

B)-N12°33'6.78"/E 25° 2'53.62"E

C)-N12°29'59.07”/E 24°57'59.12"E

D)-N12°29'49.69/E 25° 3'0.74"E

The ASTER images (acquired in the VNIR and SWIR regions/**July 29/2012**) make by (***Dr. Ebraheem E. Jordan and others***) have been

used in correlation with field sampling and chemical analysis to support the processes. A new approach of spectral unmixing of the ASTER images data using the ENVI4.8 identified and delineated areas rich in calcites. The sub-pixel estimates of calcite elements in the limestone area match well with the geochemistry of the samples collected from the study area. The spectral unmixing of Hyperspectral satellite data in the VNIR and SWIR regions may be combined with the terrain parameters to, not only target limestone minerals deposits accurately, but also estimate the quality of these deposits using the PCA.Much information about potential areas for mineral exploration can be provided by interpretation of surface features on aerial photographs and satellite images (Lille sand 2011). Due to the synoptic coverage and the varying spectral and spatial resolutions offered by satellites and airborne sensors (ASTER, HYPERION), Remote Sensing has proved to be an irreplaceable tool in understanding hydrothermal and alter environments then targeting mineral habitats. From remotely sensed data, it is possible to decipher the regional litho logy, tectonic fabric and also the geomorphic details of a terrain, which aid precisely in targeting of metals and minerals.

Geoprocessing

Sequential Image extraction algorithm has been developed to displays different topographic features like drainage systems (**fig 3-18**); watershed **(fig 18**);.

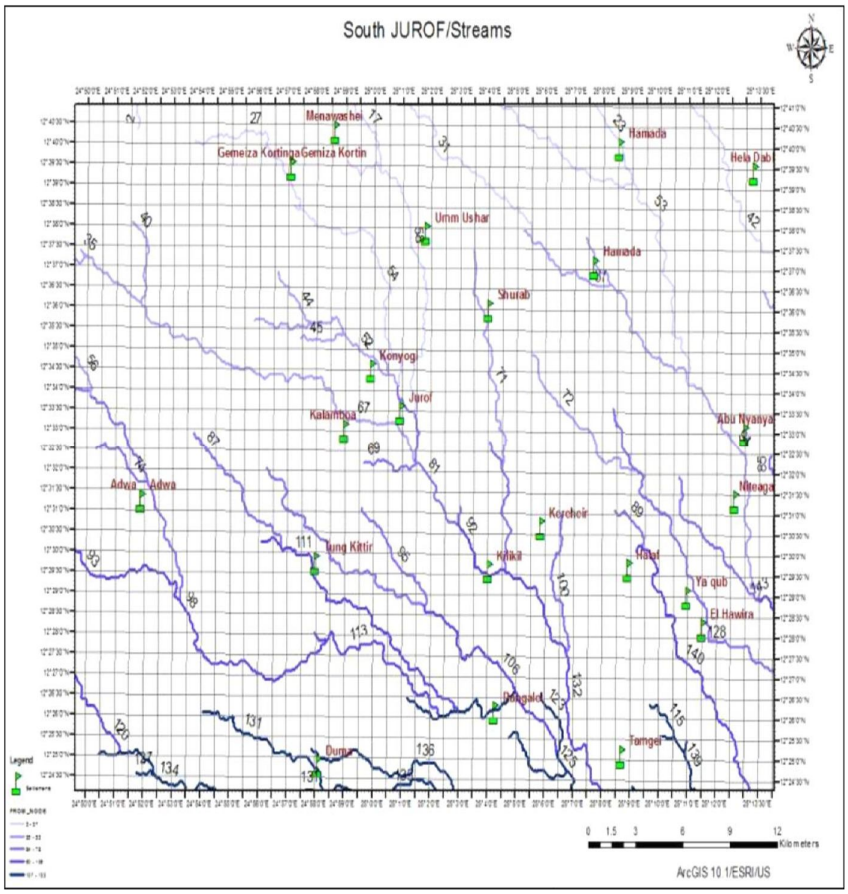


Fig 17. Drainage system map

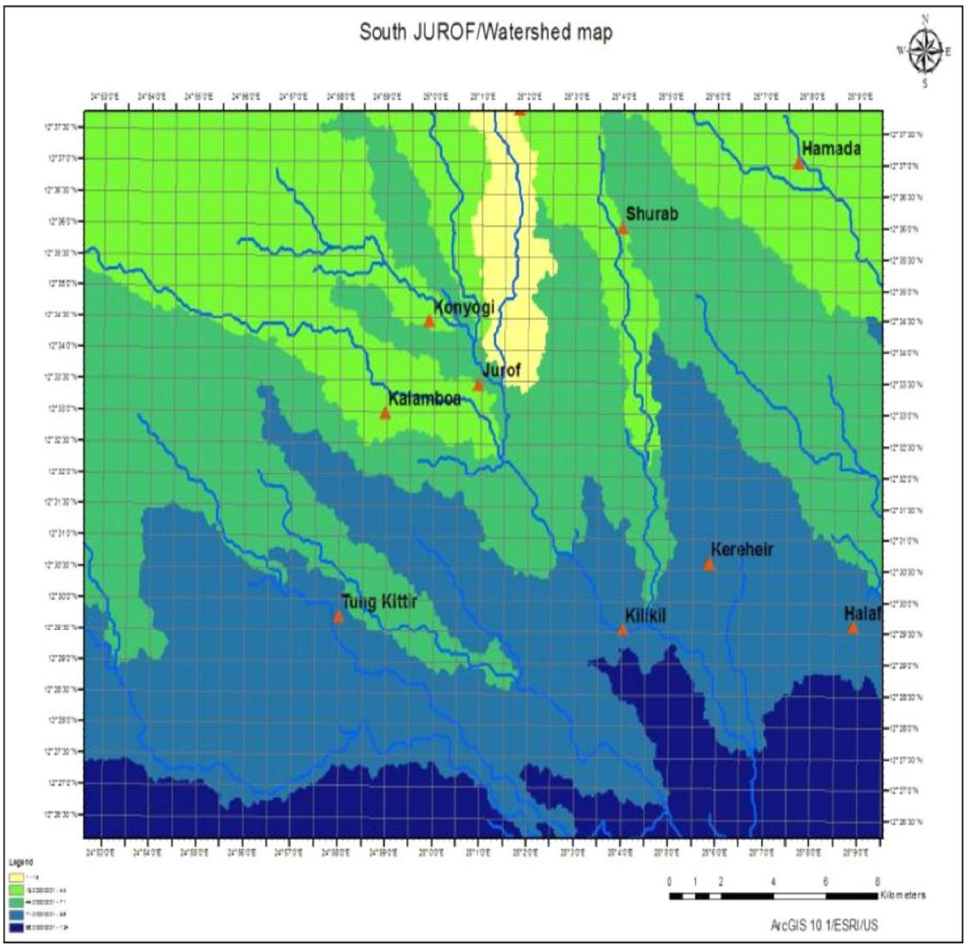


Fig 18. Water shed map in jourf area

Geology and Structure

The area is mainly composed of Mica schist and Quartz marble in the North East, granite basement in the center and common gneiss (fig.19)

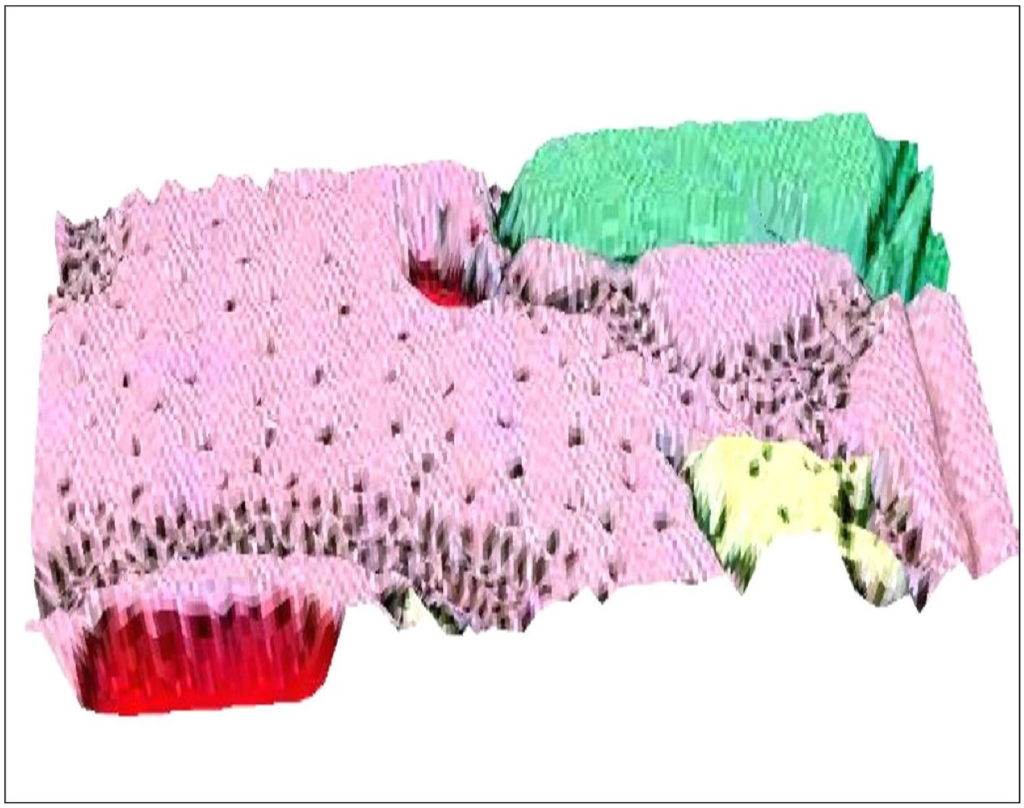


Fig 19 Geology structure marble in jourf area

Principal components analysis map(target area) :

The principal components analysis mixed the SWIR, VNIR into the map algebra with the spectral reflectance to identi the target area with high potentiality of calcite carbonate and magnetite

3.5.6 .Result of limestone Deposits

This model concludes that spectral unmixing of Hyperspectral satellite image in the VNIR and SWIR regions may be combined with the terrain parameters to target limestone and other mineral deposits like ores.The accuracy assessment featuring gravity map to move through the exploration of cement in this area.