MINISTRY OF ENERGY AND MINERAL RESOURCES
Mineral Status and Future Opportunity

BASALT

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Basalt

1. Introduction

Basalt is a common gray to black volcanic rock. It's usually fine grained due to rapid cooling of lava on the earth's surface. It may be porphyritic containing larger crystals in a fine matrix or vesicular, or frothy scoria. Un-weathered basalt is black to gray.

The mineralogy of basalt is characterized by a presence mainly of calcic plagioclase feldspar and pyroxene. Olivine can also be a significant constituent. Accessory minerals present in relatively minor amounts include iron oxides such as magnetite, ilmenite and iron-titanium oxides (Titanium-augite, sphene) and spinel.

2. Uses of Basalt

The industrial applications of basalt are based on the basic quality properties of basalt such as high abrasion resistance, compressive strength and chemical resistance.

Basalt can made into fine, superfine and ultra fine fibers, basalt fibers are considered superior to other fibers in terms of thermal stability, heat and sound insulation properties, vibration resistance and durability.

Basalt continuous fibers offer the prospect of a completely new range of composite materials and products, such products have no toxic re-action with air or water, are non combustible and explosion proof, when it contact with other chemicals they produce no chemical reactions that may damage health or environment.

Basalt replaces almost all applications of asbestos and has three times heat reinforced plastics (1 kg. of basalt reinforcement equal 9 kg. steel).

Basalt typical applications: Crushed stone, concrete aggregates, railroad ballast, production of high quality textile fibers, floor tiles, acid – resistance equipment for heavy industrial use, rock wool, basalt plastic pipers, basalt plastic reinforcement bars, basalt fibers, roofing felt, heat insulating basalt fiber materials and glass wool….etc.

3. Location

Basalt rocks in Jordan can be roughly divided into three groups: plateau basalts Harrat ash Shaam in north eastern Jordan, basalts relating to the Dead Sea rift, and finally isolated basalt effusions in central Jordan, mostly bound to deep faults. In addition to these areas, basalt are also known in other places in the form of dykes or sills and other minor bodies, Basalt occurs in different localities in Jordan, but the most important locations are Tell Burma and Jabel Uneiza, about 170km south of Amman in Jurf Ed-Darawish map sheet area. Basalt locations in Jordan are shown in Figure (1).

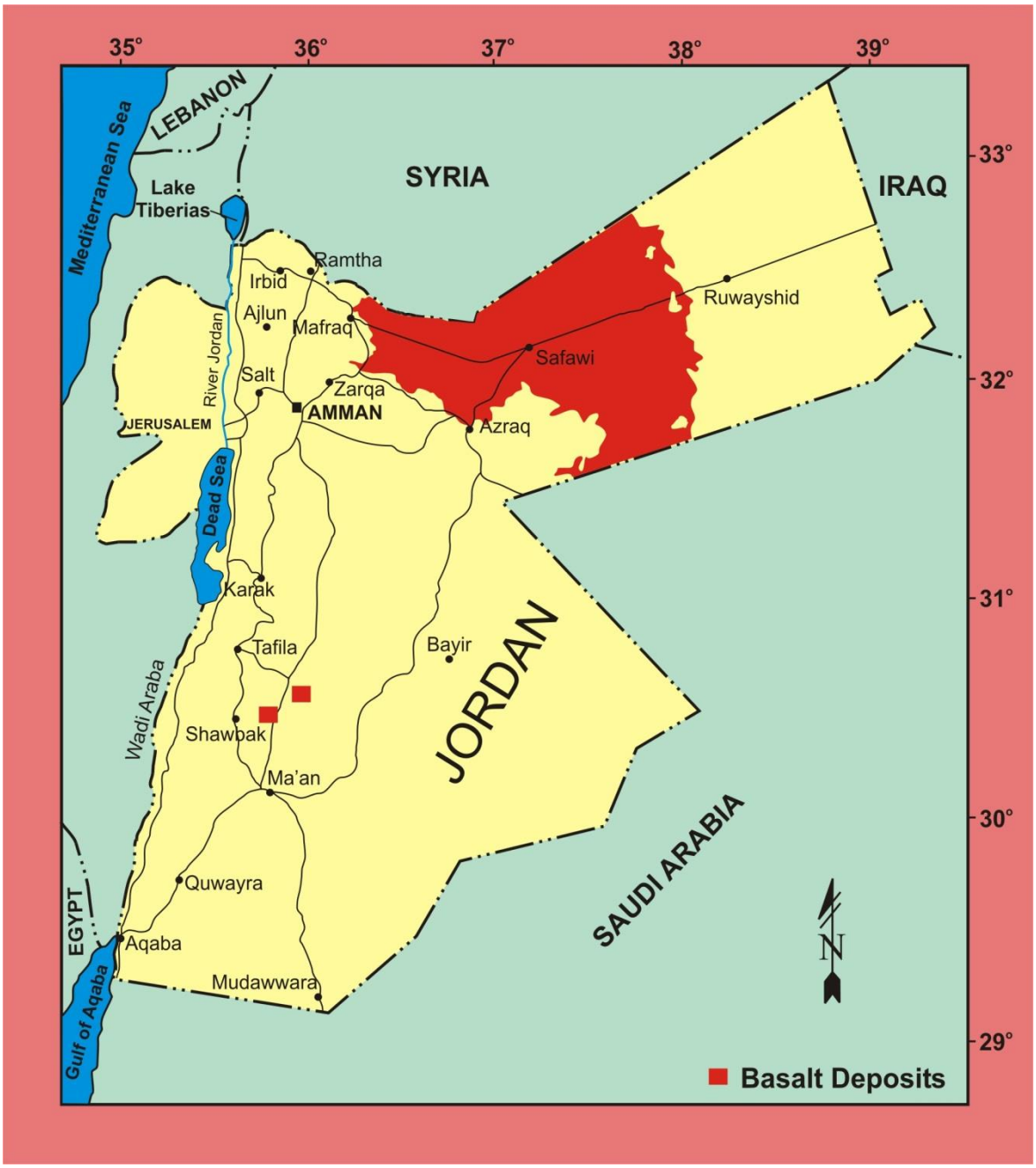


Figure (1): Basalt occurrences in Jordan.

4. Geological Settings

4.1. Plateau Basalt Northeast of Jordan

The largest area of plateau basalts in the north-eastern part of the country belongs to the north Arabian volcanic province, passing to the territories of Syria and Saudi Arabia covered an area of about 12000km^2. The effusions are bound to deep faults NW-SE course in parallel with Dead Sea rift. Intercontinental effusions, they are of Neogene to Pleistocene age. Geological map in the appendix shows the basalt in northeast of Jordan.

The sequence of particular formations from the youngest to the oldest rocks as follow:

Formation	**Group**
Fahda vesicular basalt (FA)	BISHRIYYA
Wadi Manasif basalt (WMF)	(BY)
Aritayn volcanoclastic (AT)	RI
Hassan scoriaceous (HN)	(RH)
Mahada basalt (M)	ASFAR
Mahdala olivine phyric basalt (MOB)	ASFAR
Hashimyya Aphanetic basalt (HAB)	
Ushayhib olivine pyroxene phyric basalt (UB)	
Ufayhim xenolithic basalt (UM)	
Salaman Flood basalt (SN)	SAFAWI (SW)
Abed olivine phyric basalt (AOB)	
Ali Doleritic Trachytic basalt (AI)	

4.2. The Dead Sea Rift Basalt

They are bound to the tectonics relating to this quickly deepening rift, in particular to the EW faults perpendicular to the rift. The following formation has been classified during the mapping of basalt effusion (A. Masri 1996).

- Judaiyida basalt
- Sanina basalt
- Bal'ua basalt
- Fraywan basalt

The uppermost Judaiyida basalt is probably of Quaternary age, the three lower ones are dated as Pliocene ones, and all of them are lava flows of the Jabel Shihan volcano. Geological map in the appendix shows the basalt in Dead Sea Rift.

4.3. Basalt of Central Jordan

Basalt in central Jordan represented in three areas, Tell Burma, Jabel uneiza and wadi Hisa.

The Tell Burma locality is represented by lava effusions at the eastern part of a cone. In totally they cover an area off approximately 6km^2 the lava effusions are disturbed at NE and SW sides by two shoulders of Wadi Burma.

The relatively ages were of effusions particularly depending on the basis of field observations. It is evident that part of lavas is covered with gravels considered to be of the Pleistocene age.

The Jebel Uneiza locality is again formed of an older Caldera, it extent and cover an area of approximately 1km^2, no stratigraphic conclusions can be detected fault of the same name. Geological map in the appendix shows the basalt in central Jordan.

5. Exploration Activities

Based on a good results obtained from the study of Geoindustria Company which considered Tell Burma is the most promising areas and due to their recommendations to carry out an exploration plan in order to evaluate the Tell Burma basalt, Natural Resources Authority was carried out in 2002 a detailed drilling program which include drilling twelve boreholes (Figure 2), sampling of the core, chemical analyses of these samples and ore reserve estimated.

A total of 12 boreholes were drilled, Table (1). Shows B.H No., coordinates elevation & total depth of the boreholes.

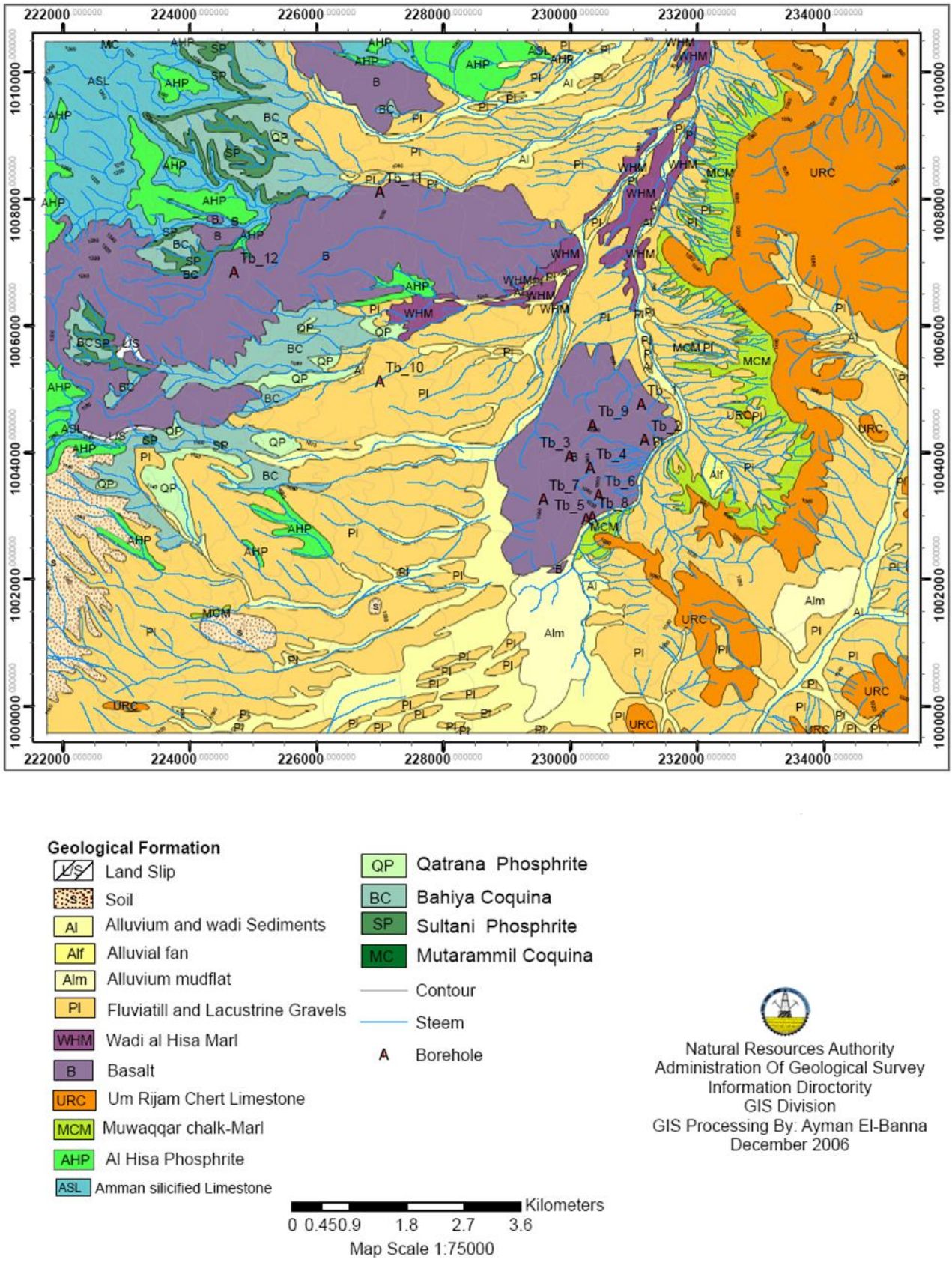


Figure (2): Geological map of Tell Burma area shows boreholes location.

Table (1): Number of boreholes, coordinates, elevations, total depth & thickness of basalt.

Borehole No	Coordinates (Palestine belt)		Elevation	Total depth (m)	Basalt thickness (m)
	East	North			
TB_1	231.120	1004.762	1037	21.0	**17.5**
TB_2	231.177	1004.209	1044	19.5	**18.2**
TB_3	229.994	1003.938	1061	31.0	**30.5**
TB_4	230.312	1003.761	1065	46.0	**40.3**
TB_5	230.250	1002.954	1053	19.3	**17.3**
TB_6	230.450	1003.334	1057	19.0	**2.5**
TB_7	229.570	1003.277	1027	9.0	**0.7**
TB_8	230.343	1002.991	1047	30.0	**29**
TB_9	230.343	1004.438	1041	30.0	**22**
TB_10	226.996	1005.125	1021	21.0	**17**
TB_11	222.996	1008.124	1063	25.0	**-**
TB_12	224.702	1006.854	1170	10.0	**-**

6. Reserve

The geological reserves of Jordanian Basalt not estimated except Tell Burma area in central part of Jordan due to the drilling activities carried out by NRA, the geological reserves in this area was estimated about 310 Mt.

7. Mineral Properties

7.1. Chemical Properties

Table (2) shows the chemical analyses of Tell Burma basalt compared with the standard chemical analyses of basalt using in casting industry in Czech Republic

Table (2): Chemical composition of Basalt in Czech Republic compared with chemical composition of Basalt from Tell Burma area in Jordan.

Major Elements	Czech Republic Basalt	Tell Burma Basalt
	Weight %	Weight %
SiO_2	43.5- 47.0	40.04-43.05
TiO_2	2.0 - 3.5	2.76-3.34
Al_2O_3	11.0 - 13.0	11.8-12.7
Fe_2O_3	4.0 - 7.0	13.2-14.3
FeO	5.0 - 8.0	------
MnO	0.2 - 0.3	0.19-0.22
MgO	8.0 - 11.0	9.15-9.82
CaO	10.0 - 12.0	9.9-11.8
Na_2O	2.0 - 3.5	0.63-2.53
K_2O	1.0 - 2.0	0.53-1.29
P_2O_5	0.5 - 1.0	0.57-0.65

7.2. Mineralogical Properties

Main components: Plagioclase, Clinopyroxene, Olivine, and Ore minerals (Magnetite and Ilmenite). Some amount of Orthoclase is present and secondary Calcite occurs.

8. Industrial Application Tests

In year 2000 and within the cooperation program between Natural Resources Authority and Geo industria company from Czech Republic, several sample of basalt from different locations of Jordan were tested in order to determine their suitability for industrial uses.

Samples were crushed in jaw crushers in order to samples of basalt rocks from different locations were collected by NRA staff and Geoindustria company staff, these samples were subjected to the technical tests in order to study their suitability for the production of castings. Sample locations are shown in Table (3).

Table (3): Samples were collected by Geoindustria Company.

Sample No.	Location
B2	North east Azraq
B6	Near the Safawi – Al- Rowaished road
B11	Along the Dead Sea shore to Aqaba
B13	Tell Burma, Ma'an District
B15	Jabel Uneiza, Ma'an District
B17	Wadi Al- Hisa

The preparatory work (drying, crushing, milling, homhgenization and quartation) and chemical analysis were made in the Gematest laboratories (Czech Republic).

All samples were dried and crushed in jaw crushers in order to get fraction < 3mm. This was followed by quartation and the portion for chemical analyses was milled in order to get grain size less than 0.063mm.

Chemical Analysis: All samples were analyzed for chemical analyses; Table (4) shows the results of analyses:

Table (4): Results of chemical analyses of samples were collected by Geoindustria Company.

Sample No.	L.O.I %	SiO_2 %	Al_2O_3 %	TiO_2 %	CaO %	MgO %	Na_2O %	K_2O %	MnO %	P_2O_5 %	FeO %	Fe_2O_3 %
B2	0.85	44.44	14.38	2.32	10.51	9.41	2.94	0.89	0.15	0.74	7.76	4.37
B6	1.48	45.28	13.90	2.32	11.27	8.63	2.79	1.07	0.14	0.74	9.44	1.39
B11	0.43	44.82	13.78	2.82	9.70	8.47	4.29	1.74	0.15	1.11	7.97	3.45
B13	2.98	41.45	11.93	3.02	12.23	8.68	3.67	0.96	0.15	1.30	7.62	4.84
B15	2.08	41.02	11.15	2.98	11.15	13.34	3.25	1.01	0.15	1.12	6.97	4.91
B17	1.30	41.54	12.67	2.64	12.32	10.98	3.88	0.90	0.15	1.44	5.46	6.01

Melting Tests: Samples were fine crushed and the material weighing about 15 kg. Put into a crucible made from a special super alloy. Then the crucible put in a laboratory furnace preheated at 1200ºC. The thermal regime allowed the rise of temperature to 1300ºC. approximately within an hour and the furnace was kept at this temperature level for three minutes. After that a crucible containing melt was taken out of a furnace, the melt was mixed and a tile sized 200x200x30mm cast into a preheated metallic mould and a small block cast into a fire clay mould sized 60x60x30mm. After setting a tile was put into an annealing kiln at a starting temperature of 850ºC and slowly cooled down for 19 hours.

A small block was kept for one hour at a temperature of 600ºC in a laboratory furnace, which then spontaneously cooled down for approximately 24 hours to reach an ambient temperature. Cooled samples were assessed visually, and a sample was cut of a tile for determination of bulk density, wear and abrasion resistance for the cast and melted, results of these tests are shown in tables (5&6).

Table (5): Basic parameters of cast basalt.

Sample No.	Bulk Density kg. m^3	Abrasion (DIN 52108) $cm^3/50cm^3$	Wear Resistance EN (102) mm2
B6	2575	12.6	156
B11	2994	6.1	116
B15	2976	4.9	95
B17	2951	5.2	102

Table (6): Basic parameters of Melted basalt.

Sample No.	Bulk Density kg. m^3	Abrasion (DIN 52108) $cm^3/50cm^3$	Wear Resistance (EN 102) mm^2
B13	3023	5.8	116
B17	2999	4.9	116

In order to determination of the most suitable raw material, results of chemical analyses and mineralogical composition of the samples were assessed and calculated according to a special equation so–called Brath's equation. The optimal value of this equation ranges from 124–136. Values of samples according to Brath's equation are presented in Table (7).

Table (7): Sample No., Brath's Value and Casting test results.

Sample No.	Brath value	Casting test
B6	105	Inconvenient
B11	121	Inconvenient
B13/1	141	
B13/2	127	Good
B13/3	131	Good
B15	135	Good
B17	133	Middle

On the basis of the evaluation of melting and crystallization results and taking into consideration the chemical and petrographic analyses it can be stated that sample B6 (Near Safawi area) is entirely unsuitable for the production of casting. The remaining samples show much better properties and can be ranked rising as follows: B11, B17, and B15. Sample B15 it seems to be the most promising. Samples from Tell Burma area (B13) have good results, which considered a promising area.

9. Background

Many studies have been carried out on the basalt in Jordan; these studies are including the flowing:

- In the year 1985 Safarini performed a study on basalt in the central part of Jordan, the study revealed that the basalts are of alkali olivine basaltic type.

- In the year (1987) Khalil Ibrahim carried out a study on basalt in the central regions of the Kingdom, including Tell Burma and Uneiza mountain shown that the nature of basalt (Sodic alkalic) and the source is the upper part of the shell 50-60km, where the temperature reaches to amore than 1050ºC which has led to eruptions during the period (Pliocene – Pleistocene).

- GIS Geo industry (2000) carried out a study on the Jordanian basalts to know if this basalt can be used in moulds plumbing and pipe manufacturing or not?

- In the year (2001) khalil Ibrahim, Ibrahim Rabba and khalid Tarawneh, prepared a geological and mineral occurrences map of the northern Badia region, Jordan.

- In the year 2006 of A. Abu Salah, N. Mehyar and I. Russan, studied the occurrences and estimated the reserves of basalt in Tell Burma and Jabal Uneiza south of Jordan.

10. Investment Opportunities

10.1. Rock Wool Industry

Basalt can be used as an input raw material for the manufacture of rock wool. The latter is sold both domestically and exported and is used mainly in the building industry for insulation.

10.2. As Aggregates and Building Stones

Jordanian Rock Wool Company used the crushed basalt (25 – 45mm) for rock wool industry, and the size less than 25mm which form 30% of product used as aggregates. The uses of basalt as aggregates is still weak due to the available of alternative and cheap material such as limestone, although the physical engineering specifications of basalt are much better than limestone, therefore it consider a good investment opportunity to use basalt in this field, also basalt can be used as a dimension stones for building.

10.3. Mould Casting

Currently, there is no investment in this field, but it is a good investment opportunity to use basalt in this industry. Technological tests have been carried out by Geoindustria (Czech Republic) in 2000 on samples from Jordan (Tell Burma and Jabel Uneiza) showed that the basalt of these areas can be used as a mould casting and pipes industries, these results confirmed with the Czech Republic specifications for the same industries.

11. References

Abu Salah, A., et.al., 2006. Studies of Basalt and its reserves in the areas of Tell Burma and Jabal Unizah/ South Jordan (In Arabic).

Mining sector performance during 2004, Industrial Liaison Division 2005.

Ibrahim, K., Rabba, I., and Tarawneh, K. 2001. Geological and mineral occurrences map of the northern Badia region, Jordan

GIS GEOINDUSTRY, PRAHA CZECH REPUBLIC (2000). Geological and Technological Evaluation of Selected Mineral Resources in Jordan.

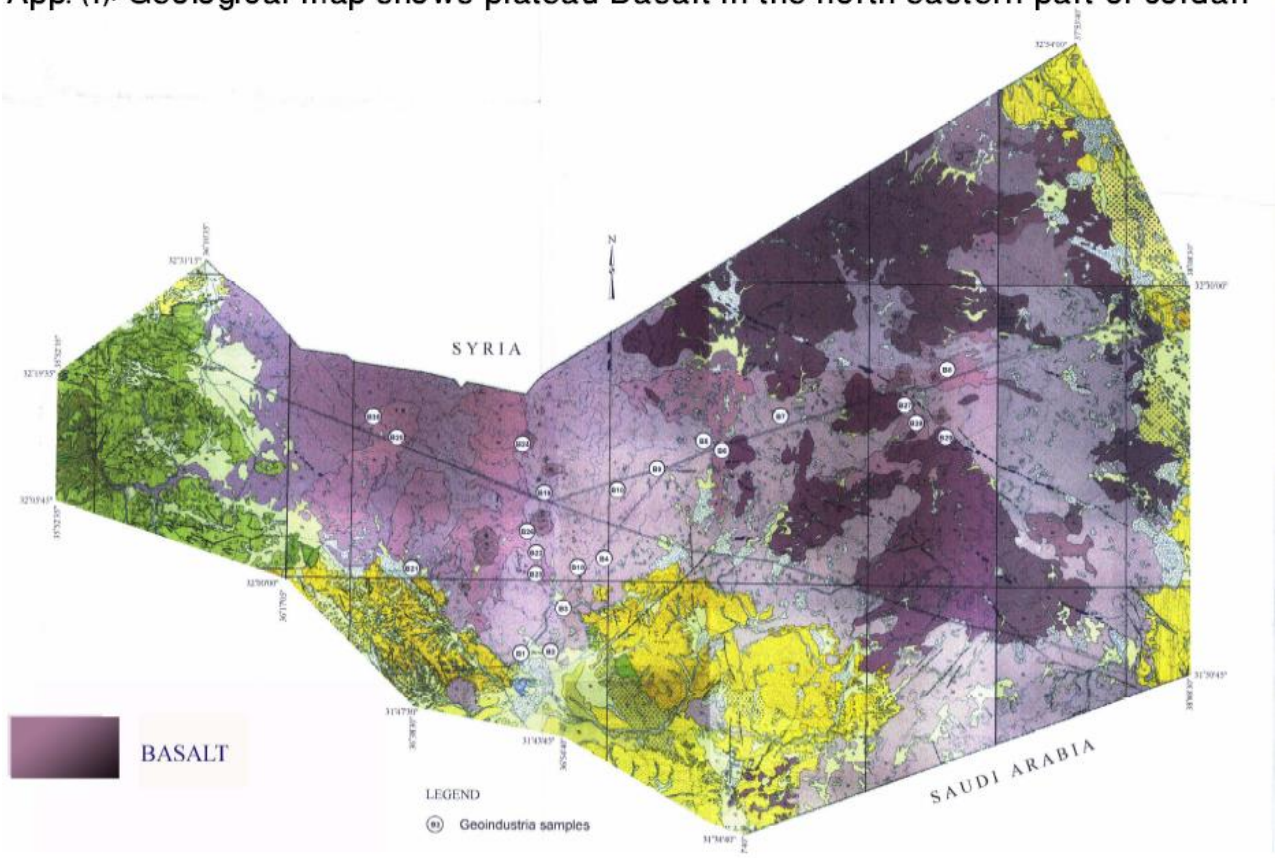
Appendices

Appendix (1): Geological map shows the basalt in Northeast of Jordan.

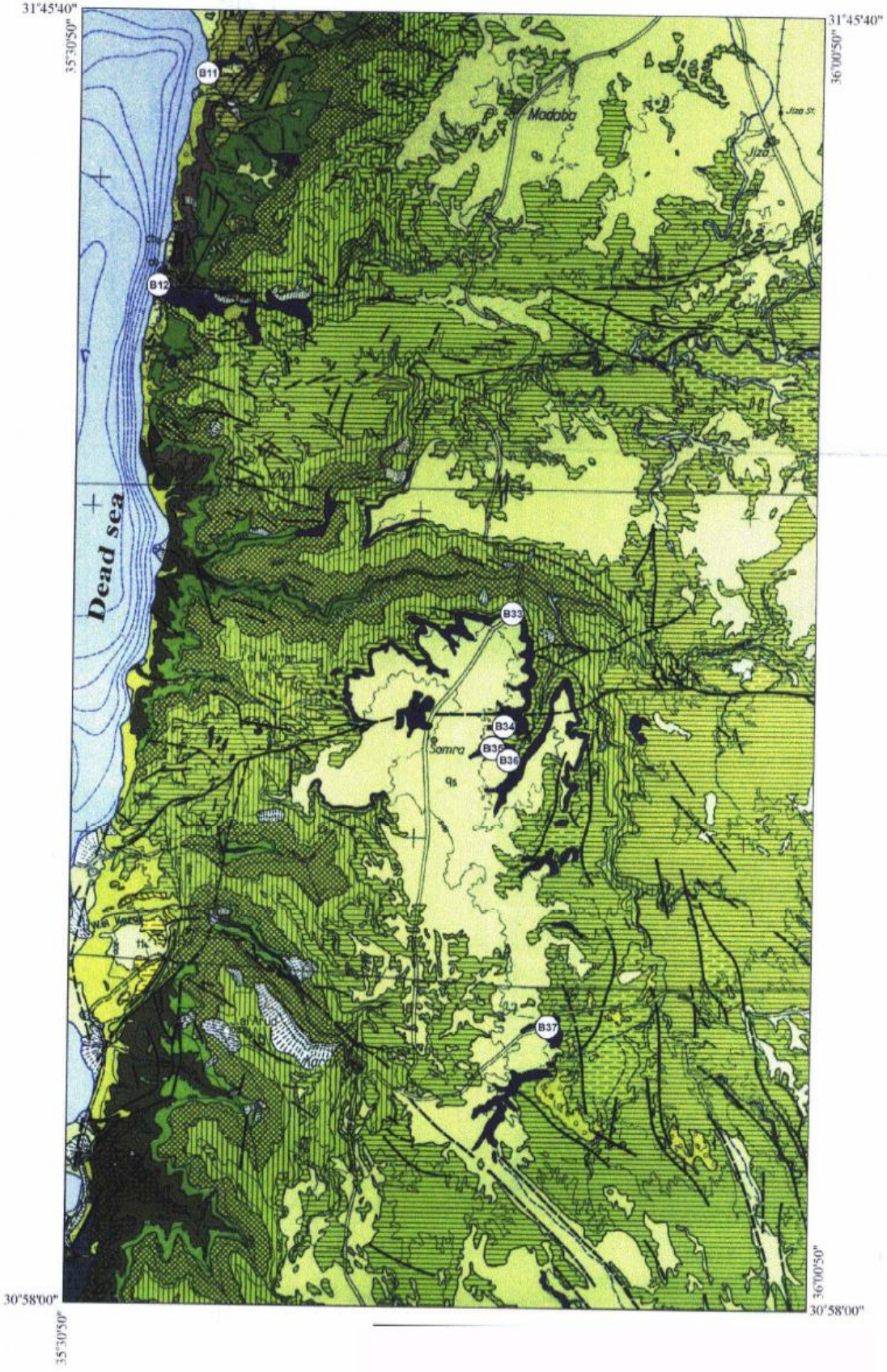
Appendix (2): Geological map shows the basalt in Dead Sea Rift.

Appendix (3): Geological map shows the basalt in Central Jordan.

App. (1): Geological map shows plateau Basalt in the north eastern part of Jordan



App. (2): Geological map shows the Basalt in Dead Sea Rif



App. (3): Geological map shows basalt of central Jordan