Remediation of metal and hydrocarbon contaminated sites using an organo-zeolitic soil amendment to sustain plant growth: A new dimension to the economics of phytoremediation.

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University/Business Affiliations

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A European Patent, EP 1 208 922 B1, “Method of sustaining plant growth in toxic substrates polluted with heavy metal elements” was published on 03.03.2004.

Commercial interests should be directed to: Mr Steven Forster, IEG Technologies (UK) Ltd., CUBIC, Building 45, Cranfield University, Bedfordshire MK43 0AL, UK.

Scientific questions should be directed to: Dr. Peter J.Leggo, Department of Earth Sciences, University of Cambridge, Downing Street, Cambridge CB2 3EQ, UK.

FIGURE 1

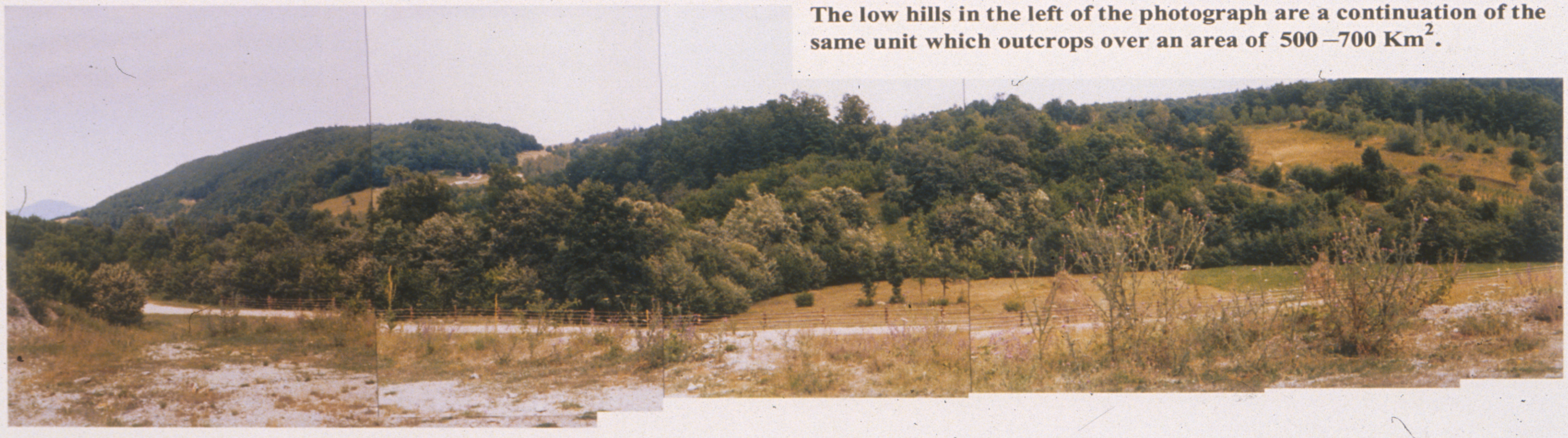
The exposure reveals 200m of the tuff bed along the roadside and drilling in the forest behind the quarry has shown the bed to be some 90m thick.

Zeolitised Tuff Outcrops in the Morri Valley

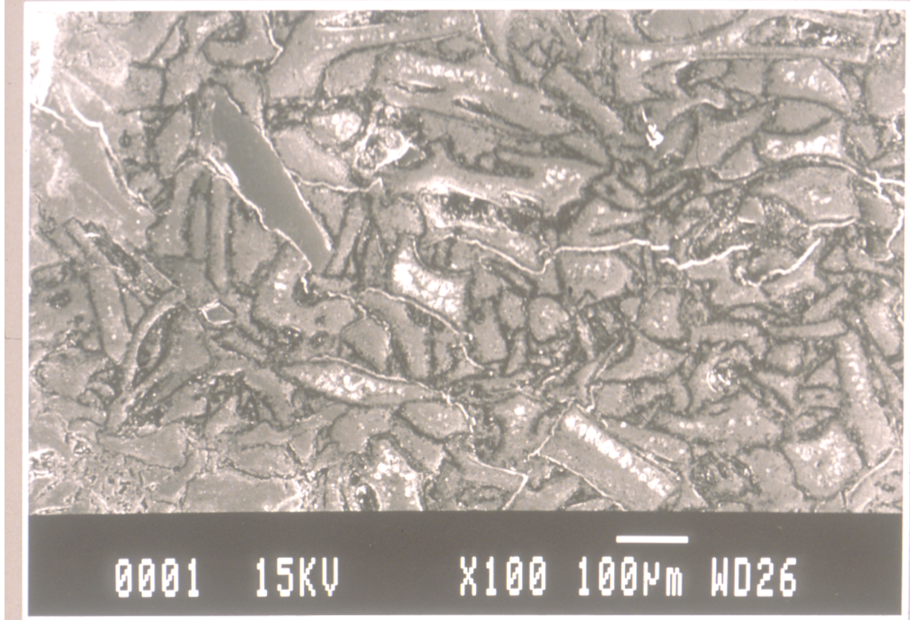
Volcaniclastic sediments of Badenian age (ca.14Myr) occur extensively throughout the Morri Valley area.

FIGURE 2

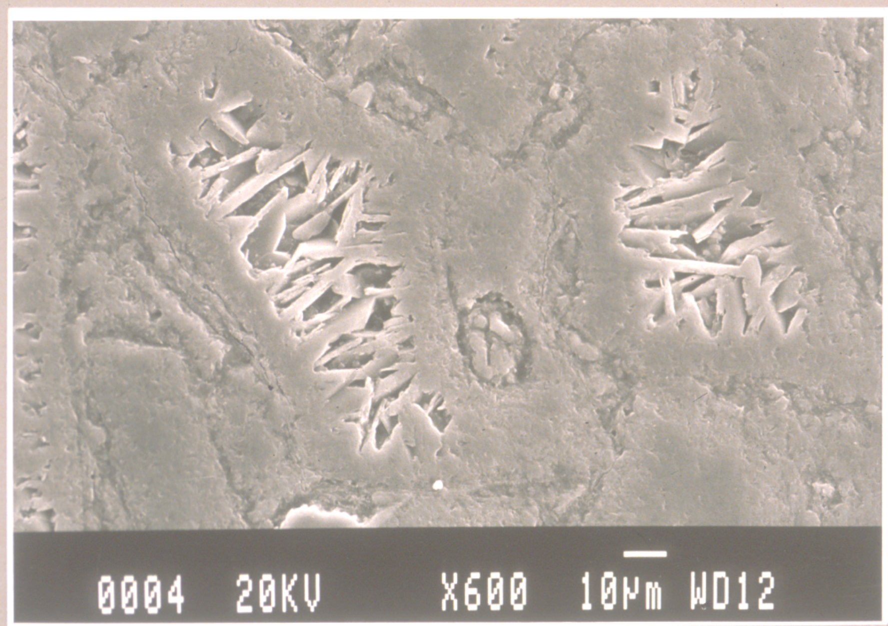
The low hills in the left of the photograph are a continuation of the same unit which outcrops over an area of 500 –700 Km^2.

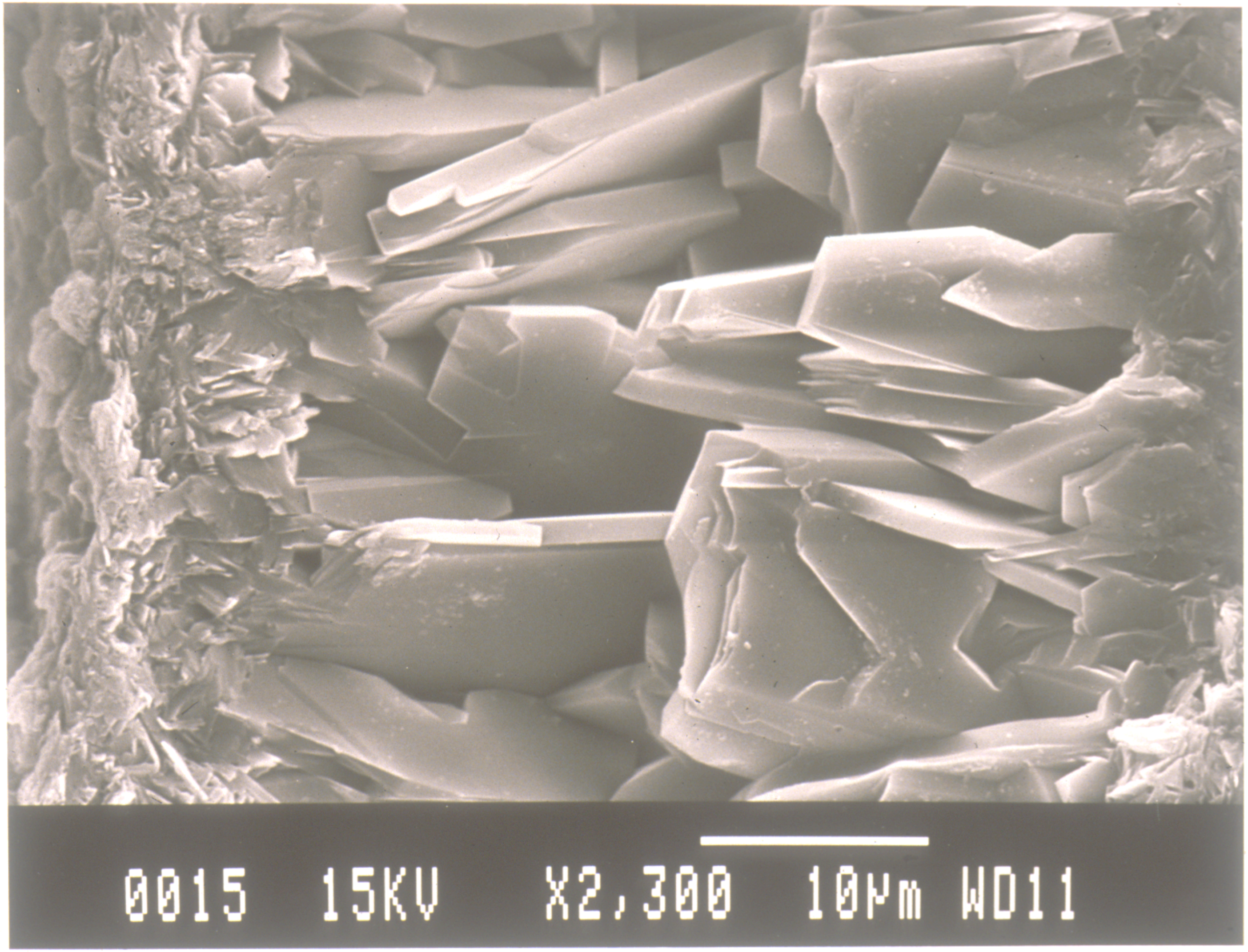


1. SEM image of a zeolitic tuff grain



2. Close - up of zeolitized glass shards

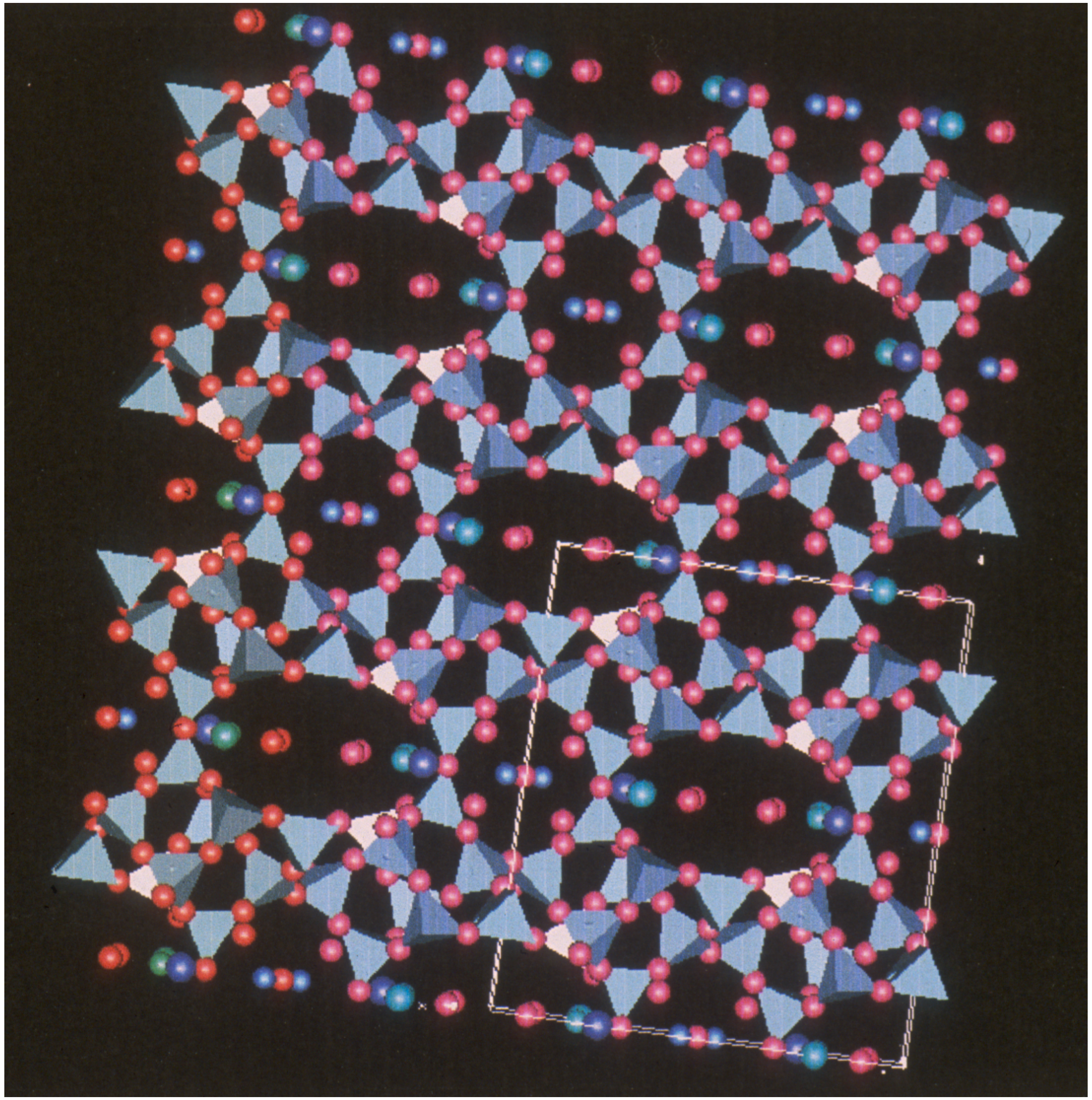




Highly magnified image of clinoptilolite plates surrounded by clay minerals

Clinoptilolite open - framework structure

The black elliptical spaces represent channels in the structure in which water molecules and extra framework cations are loosely held and are therefore exchangeable.

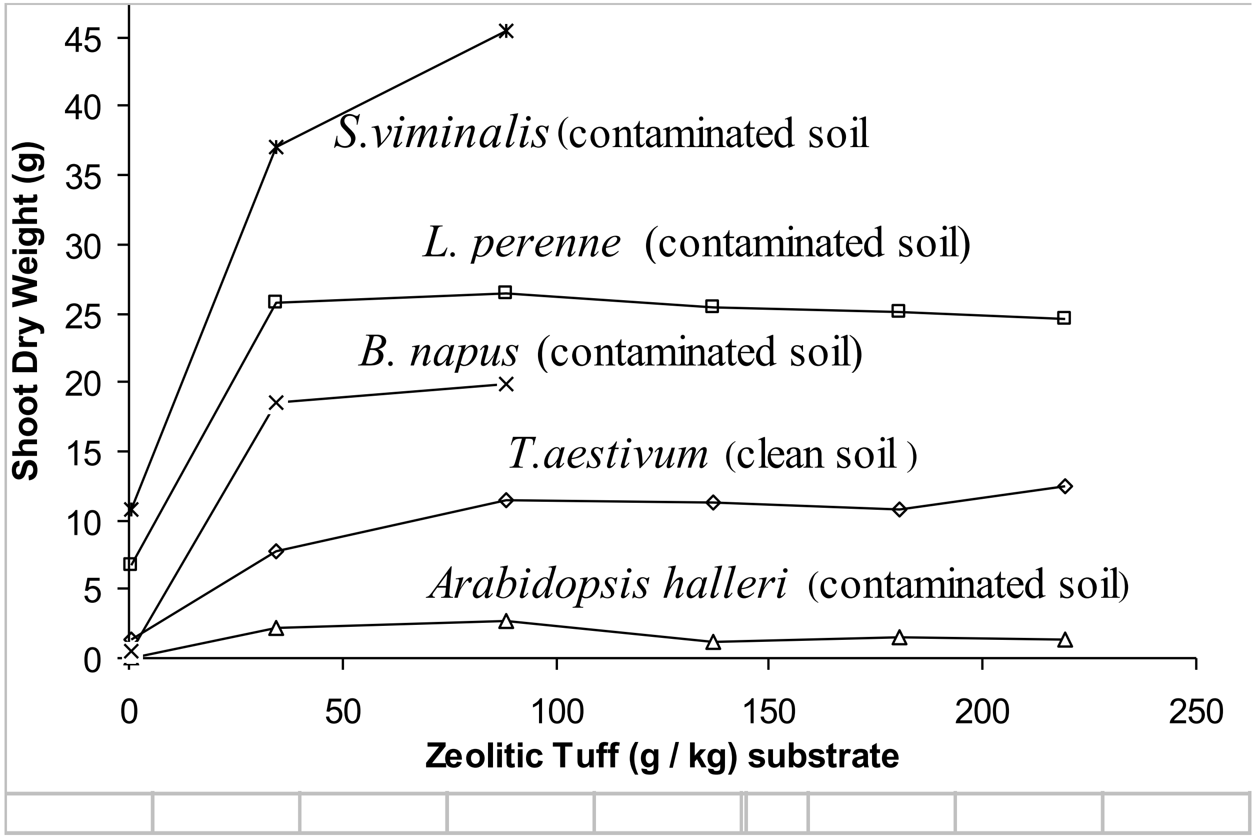


Leachate Data, concentration of available nitrogen species (mg/l) and electrical conductivity (μ S/ cm) .

Sample	NH4+	NO2 -	NO3-	EC
CG-1 (1st week)	**1.2**	**0.1**	**0.2**	**117**
CG-1 (2nd week)	**2.6**	**0.2**	**0.1**	**138**
CG-1 (3rd week)	**0.5**	**0.2**	**0.5**	**108**
CG-1 (4th week)	**1.2**	**0.2**	**1.9**	**105**
OZ-A1 (1st week)	**1.9**	**0.1**	**355.0**	**3200**
OZ-A1 (2nd week)	**1.4**	**0.1**	**330.6**	**3000**
OZ-A1 (3rd week	**1.3**	**0.3**	**351.5**	**3850**
OZ-A1 (4th week)	**1.6**	**0.2**	**410.3**	**3370**

CG refers to Garden Soil control.
OZ-A Graden Soil amended with 16.7 Vol % Organo-zeolitic mixture. The values quoted are arithmetic means of four replicate analysis in each case. Standard deviation ca. 10%

Plant growth trend in organo-zeolitic amended substrates.



FRON GOCH, Central Wales Mine Waste Experiment

Sample description : grey green sand.
Pore water pH value 4.0 ± 0.02. (Adjusted to pH 6.57 by addition of $5g.kg^{-1}$ $CaCO_3$)

Mine- waste chemistry, Major and trace cations, concs $(mg.kg^{-1})$

Al	As	B	Ba	Ca	Cd	Co	Cr
35120	9.34	25.1	175	158	1.23	8.10	23.9

Cu	Fe	K	Li	Mg	Mn	Mo	Na
19.1	19692	9069	165	3140	206	<7.46	1890

Ni	P	Pb	S	Se	Sr	V	Zn
13.3	133	4345	1446	<7.46	25.0	43.5	1049

Salix viminalis

Left hand pot : plant growing in Fron Goch mine waste

Right hand pot: plant growing in amended mine waste

Brassica napus. Left hand pot: plants growing in Fron Goch mine waste.

Right hand pot: plants growing in amended mine waste.

Spring wheat roots (two plants in each case) non-amended control plants to the left of scale, plants grown in organo-zeolitic substrates to the right

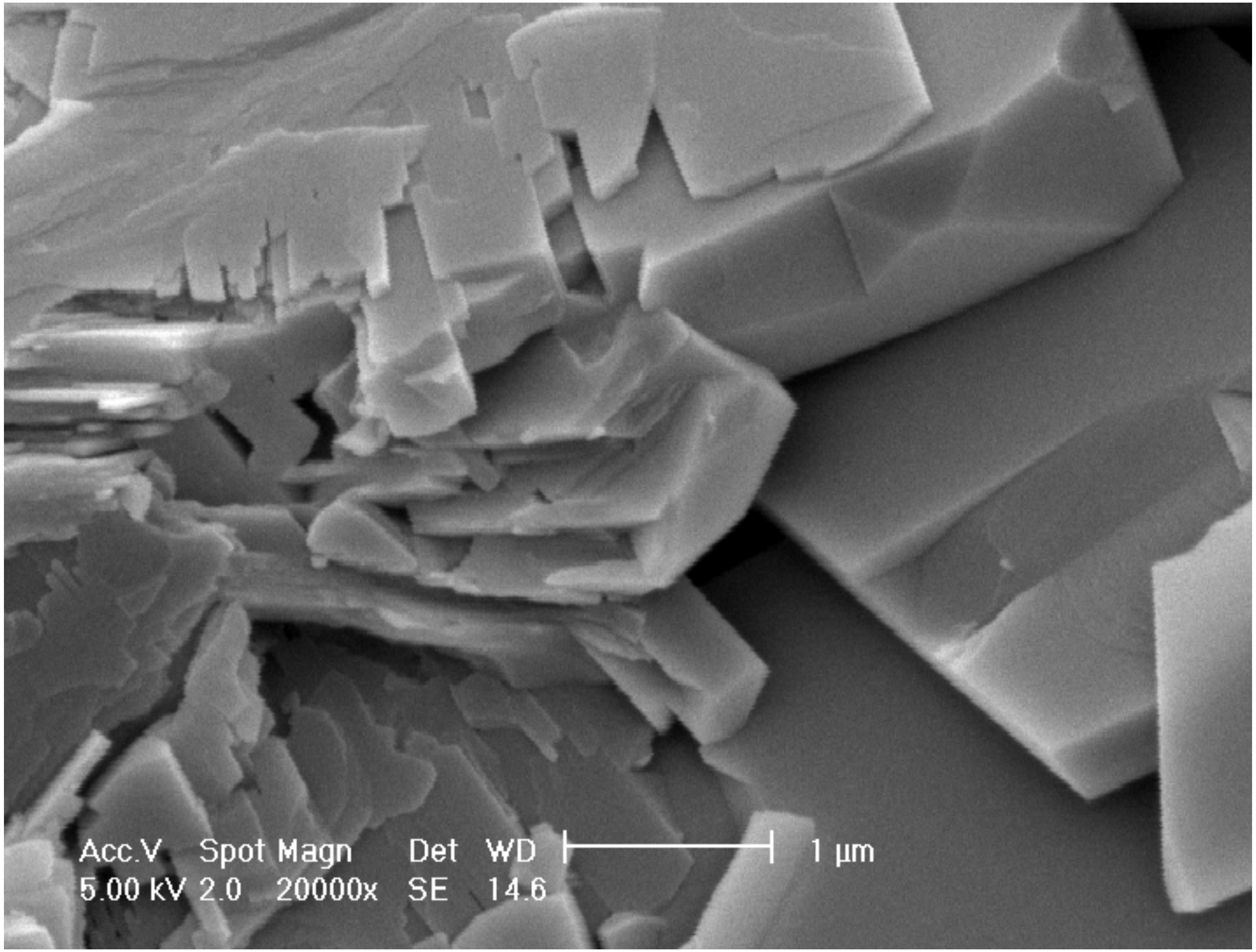
Auby metallurgical waste site, Pas de Calais, France.

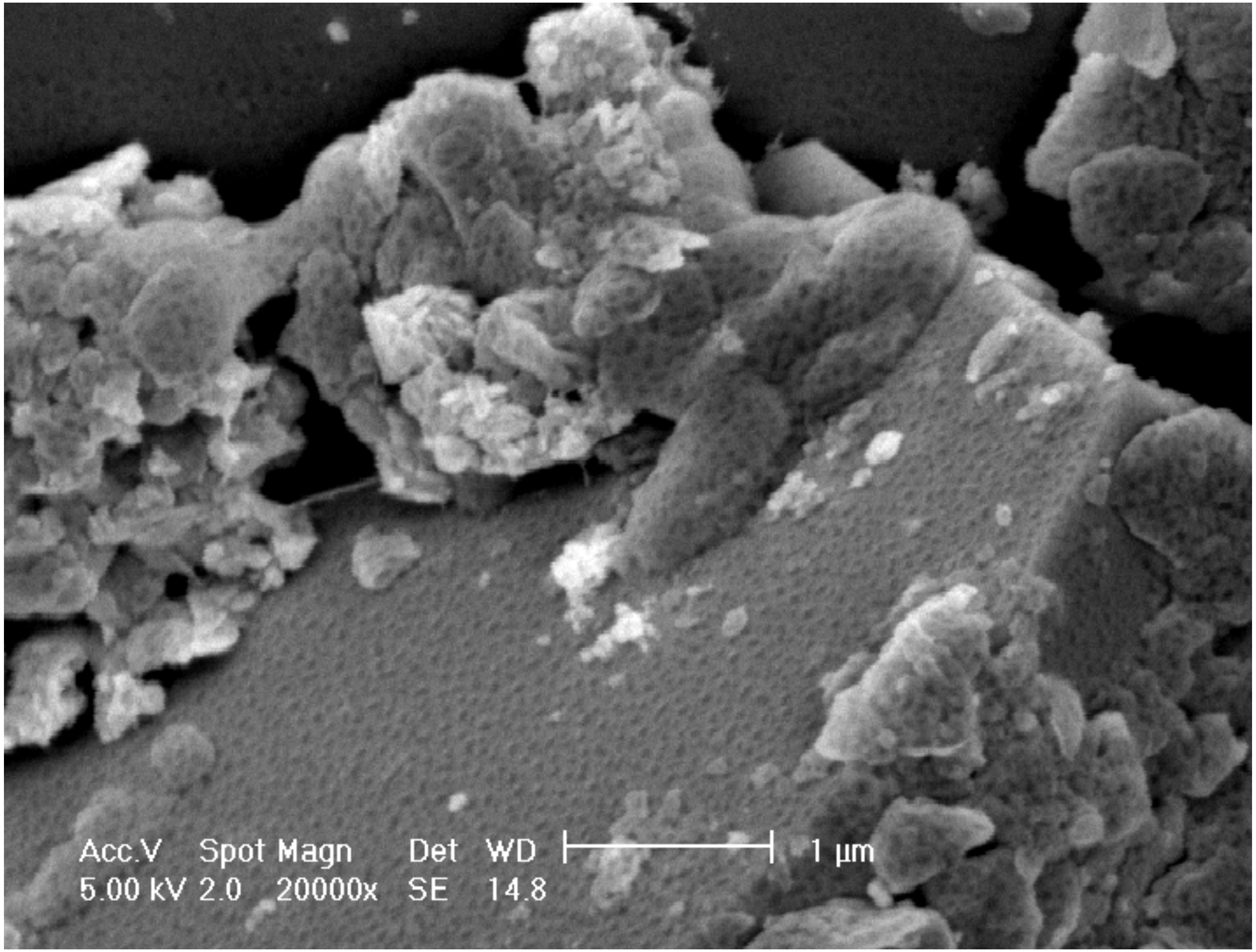
Chemistry of Mine waste: Pb 111000 $mg.kg^{-1}$, Zn 63000 $mg.kg^{-1}$,

Cd 4000 $mg.kg^{-1}$.

Arabidopsis halleri (un-treated)

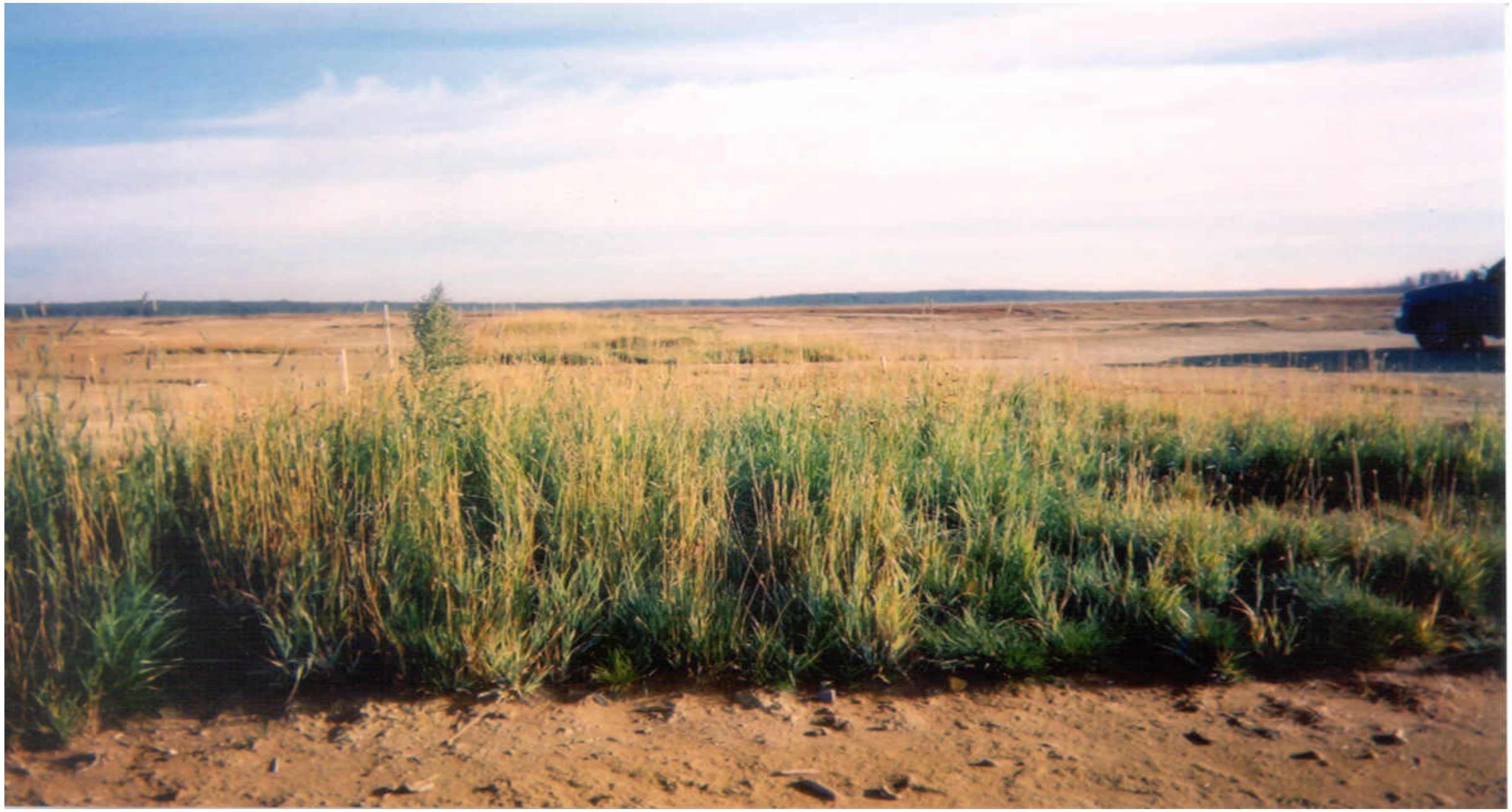
Arabidopsis halleri (treated)


Acc.V Spot Magn Det WD
5.00 kV 2.0 20000x SE 14.6
1 µm


Acc.V Spot Magn Det WD
5.00 kV 2.0 20000x SE 14.8
1 µm

Lynn Lake, Manitoba, Canada. Test site on acidic mine tailings.

The grass is now in its fifth year, has been self sustained in freezing winter conditions and has had no additional treatment what so ever.



Conclusions

- Zeolites are well known for their unique cationic exchange and surface adsorption and absorption properties.
- Many cations, such as NH4+, have reversible ion-exchange properties.
- Organo-zeolitic materials promote nitrification which, in turn, is known to facilitate the bioremediation of many recalcitrant hydrocarbons.
- Amendment with organo-zeolitic material produces a microbial ecology that can sustain plant growth, even in extreme phytotoxic conditions.
- Zeolite crystal surfaces are highly susceptible to biofilm formation.
- The organo-zeolitic-soil system will increase the scope of phytoremediation to enable plant growth to be sustained on both metal and hydrocarbon contaminated land.
- Metal contaminated land can now be cultivated to provide biofuel crops and / or ultimately returned to valuable parkland.