

**ECP 2005 CULT 038097/Bernstein**

**BERNSTEIN**

**Deliverable no. 29, ref. D6.5**  
**Digital paper studies kit**

|                            |                                 |
|----------------------------|---------------------------------|
| <b>Deliverable number</b>  | <i>D6.5</i>                     |
| <b>Dissemination level</b> | <i>Public</i>                   |
| <b>Delivery date</b>       | <i>31 January 2009</i>          |
| <b>Status</b>              | <i>Final</i>                    |
| <b>Author(s)</b>           | <i>The Bernstein Consortium</i> |



***eContentplus***

This project is funded under the *eContentplus* programme<sup>1</sup>,  
a multiannual Community programme to make digital content in Europe more accessible, usable and exploitable.

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<sup>1</sup> OJ L 79, 24.3.2005, p. 1.

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## 1 Introduction

This deliverable presents the Bernstein Paper Studies Kit (PSK). The Bernstein PSK is a collection of ready-to-use tools and data that gives people the means to set up their own digital services for paper watermark studies, such as the Bernstein concordant watermark database and the Bernstein compatible application software. The Bernstein PSK is distributed as the ‘free of charge’ package for the non-commercial usage.

The developed software package is implemented on a PC-based platform and runs under Windows XP SP3 operating system or higher. It provides the direct access to a Bernstein compatible watermark database running on a MySQL server (version 5.0.67 or higher). This database management system (DBMS) was selected to be used in the Bernstein project because nowadays a MySQL server is one of the most popular DBMS for web applications and is available as free software under the GNU General Public License (GPL) (see <http://dev.mysql.com/>). In the following chapters the structure and functionalities of the developed PSK are presented.

## 2 PSK Deployment and Installation

### 2.1 PSK Deployment

The Bernstein paper study kit is available as the downloadable compressed Windows Installer compatible package from the “Download Kit” web page of the Bernstein portal under the following URL: [http://memoryofpaper.oeaw.ac.at/kit/appl\\_start.disp](http://memoryofpaper.oeaw.ac.at/kit/appl_start.disp) (Windows and Windows Installer are the registered trade marks of the Microsoft Corporation, USA). The “Download Kit” web page contains also the supplementary deployment information including: the license agreement, the ‘README’ file, the installation guide documentation and the user manual documentation. The PSK package, the software tools and all supplementary deployment data are distributed as the ‘free of charge’ ones for the non-commercial usage.

The PSK installation package contains in a compressed form the following bundled data:

- The watermark toolkit software package (WMT);
- The data starting kit (template) of the Bernstein concordant watermark database;
- A demo version of the Bernstein concordant watermark database;
- A relatively small demo set of watermark images just sufficient to demonstrate the basic functionality of the WMT;
- A set of configuration files for the WMT package.

### 2.2 Installation

The PSK install package is the self-extracting executable file. To install the PSK the user must download and run this executable file as a Microsoft Software Installer (MSI) package. During the option selection stage of the installation, the user, guided by a sequence of the graphical interface forms, can select the destination folder of the target system for the installing software and also can select the desirable subsets of the bundled optional data to be installed. During the finishing stage the installer will copy the selected bundled data into the proper locations of the target system and will adjust, configure and update all required Windows Registry data and configuration files to tune up the WMT settings and options in accordance with the selected installation settings and options.

Screen shots of two graphical interface forms of the WMT installer are presented below: the start “Welcome” page and the “Destination Folder” selection page are shown on Figure 1 and Figure 2, respectively.

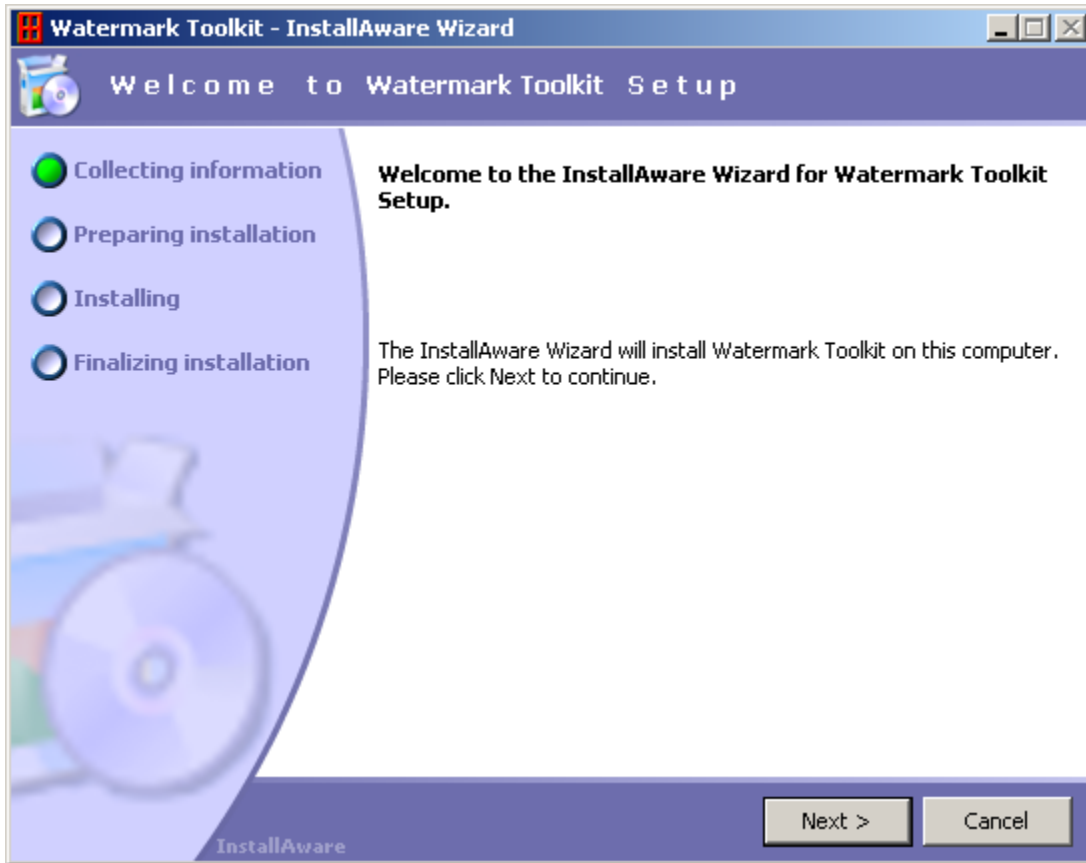


Figure 1: Screen shot of the start “Welcome” page of the WMT installer.

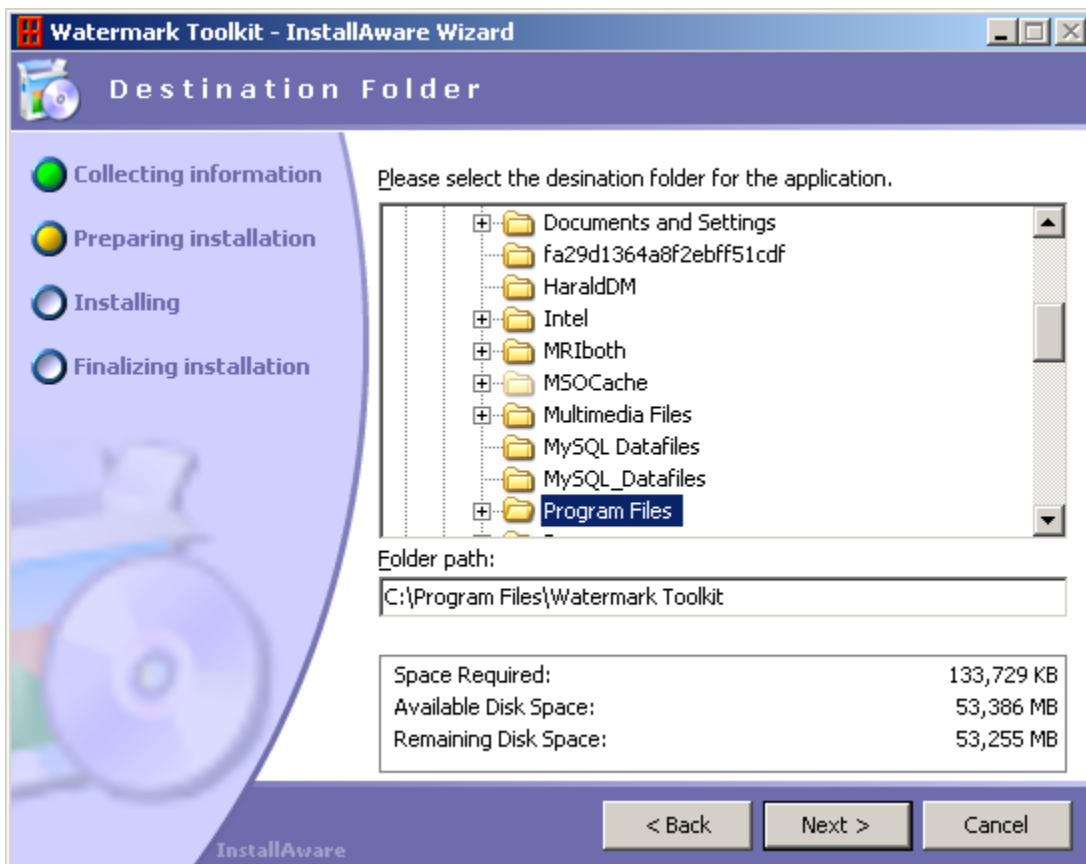


Figure 2: Screen shot of the “Destination Folder” selection page of the WMT installer.

After successful installation, the WMT package is ready to be used and connected to an active MySQL server with a running Bernstein compatible watermark database. Such a Bernstein compatible watermark database can be accessed by the WMT locally or remotely.

It should be mentioned that the currently available MySQL servers have a very sophisticated and strict privilege system to control any kind of access to the server and its data. One of the main functions of this system is authentication of a user who connects from a given host and to associate that user with privileges on a database. So, a user must have the proper privileges to get connection, populate and retrieve data (select, insert, update, etc.) to/from a running MySQL database. These privileges must be granted by the authorized administrator of the database for the user to be authenticated and get proper access to the database.

The next scenario of the WMT connection to the Bernstein compatible watermark database takes place when user has not any valid access to the existing Bernstein compatible watermark database. In such case users can use the deployed data starting kit (the template) of the watermark database to set up their own Bernstein concordant watermark database and digital services for paper watermark studies. As mentioned above, the MySQL server is available as free software. This software is downloadable, for example, from the following URL: <http://dev.mysql.com/downloads/mysql/5.0.html>. These very useful web resources have also all required documentation including installation instructions and user manuals where all steps of installation, administration and usage of the MySQL server are described in details. The corresponding reference manual (English version) can be found and downloaded, for example, from the same web site: <http://dev.mysql.com/doc/refman/5.0/en/>. The user can exploit these web resources to download, install and instantiate the MySQL server on a local or remote computer administrated by the user. Under such circumstances the user has to copy the deployed data starting kit of the watermark database into the MySQL data folder (see the MySQL reference manual for details) and grant the proper privileges for the newly activated watermark database. The instantiated by such way the database will be fully compatible with the Bernstein watermark one and can be accessed, populated and queried by the authenticated WMT user.

### 3 Bernstein Concordant Watermark Database

#### 3.1 Watermark Database Structure

The structure of the Bernstein watermark database was designed to be concordant with the requirements elaborated by the Bernstein consortium members during the Bernstein project Work Packages implementation. The development was made to minimize the quantity of tables and data fields which should enough to be conform to the requirements elaborated by the Bernstein consortium. The developed Bernstein concordant watermark database is a rational database and consists of the 14 tables listed and described in Table 1. The list of data fields and the data definition for the basic tables a given in the Appendix A.

| Table Name        | Description                                   |
|-------------------|---|
| <b>Country</b>    | The country and country code data.            |
| <b>Depository</b> | The depository of the registered watermarks.  |
| <b>Method</b>     | The method of watermark image capturing.      |
| <b>Metrics</b>    | The metric parameters of watermarks           |
| <b>Motif</b>      | The watermark motif classification data.      |
| <b>MotifIcon</b>  | The icons of the registered watermark motifs. |

|                    |   |
|--------------------|---|
| <b>Related</b>     | The data concerning related watermarks.                   |
| <b>Repertory</b>   | The repertories used for comparison of watermarks.        |
| <b>Source</b>      | The sources of the registered watermarks.                 |
| <b>SourceBase</b>  | The bundled sources of the registered watermarks.         |
| <b>TableStatus</b> | The update status of the motif table (used internally).   |
| <b>Variant</b>     | The watermarks registered as variant ones to some others. |
| <b>Wmarks</b>      | The registered watermarks.                                |
| <b>WmRep</b>       | The registered watermarks for comparison.                 |

**Table 1: The table list of the Bernstein concordant database tables.**

### 3.2 Data starting kit

The data starting kit provides an initial set of watermark data that can be used as a model on how to interact with WMT and catalog paper watermarks. Nevertheless, it contains the templates of all Bernstein database tables sufficient to set up a fully functional watermark database and watermark studies services. The structure of these tables is fully compatible with the Bernstein one. The main part of these tables is empty and only four following tables have populated data: “Country”, “Method”, “Motif” ” and “MotifIcon”.

## 4 The Watermark Toolkit

The Bernstein Watermark Toolkit (WMT) was designed, developed and implemented as an application software package for the Bernstein compatible watermark databases. The WMT realizes all routine functions required for populating, retrieving and exploiting data to/from Bernstein compatible watermark databases. The WMT gives opportunity to significantly decrease the time required for identification, classification and dating of watermarks and in such way drastically increase the efficiency of the watermark studies in this area. The key functions of the WMT are the following:

- Watermark motif classification;
- Watermark identification;
- Watermark database population;
- Measurement of watermark metric parameters;
- Watermark comparison;
- Digital image processing;
- Watermark image capturing, storing and digital processing;
- Printing service.

The WMT is implemented as a standalone program running under the Windows XP or higher operating system. The user interaction with the WMT is realized through the graphical user interface that is implemented as the multiple document interface one (MDI interface) and contains more than 50 different child interface forms. A screen shot of the main interface form with two open children interface forms: “Image under processing” and “Country, depository and source” is presented below on Figure 3 as an example of the MDI interface of the WMT. The user invokes, controls and terminates the required functionalities of the WMT through the set of the main or local pop-up menus items. The main WMT menu bar is traditionally located at the top of the main interface form (see Figure 1). Some of the key WMT functions can be simply invoke by clicking the proper button from the quick button toolbar, which is located also at the top of the main WMT window as the next row to the main menu one. The WMT contains all together about one hundred different menu items.

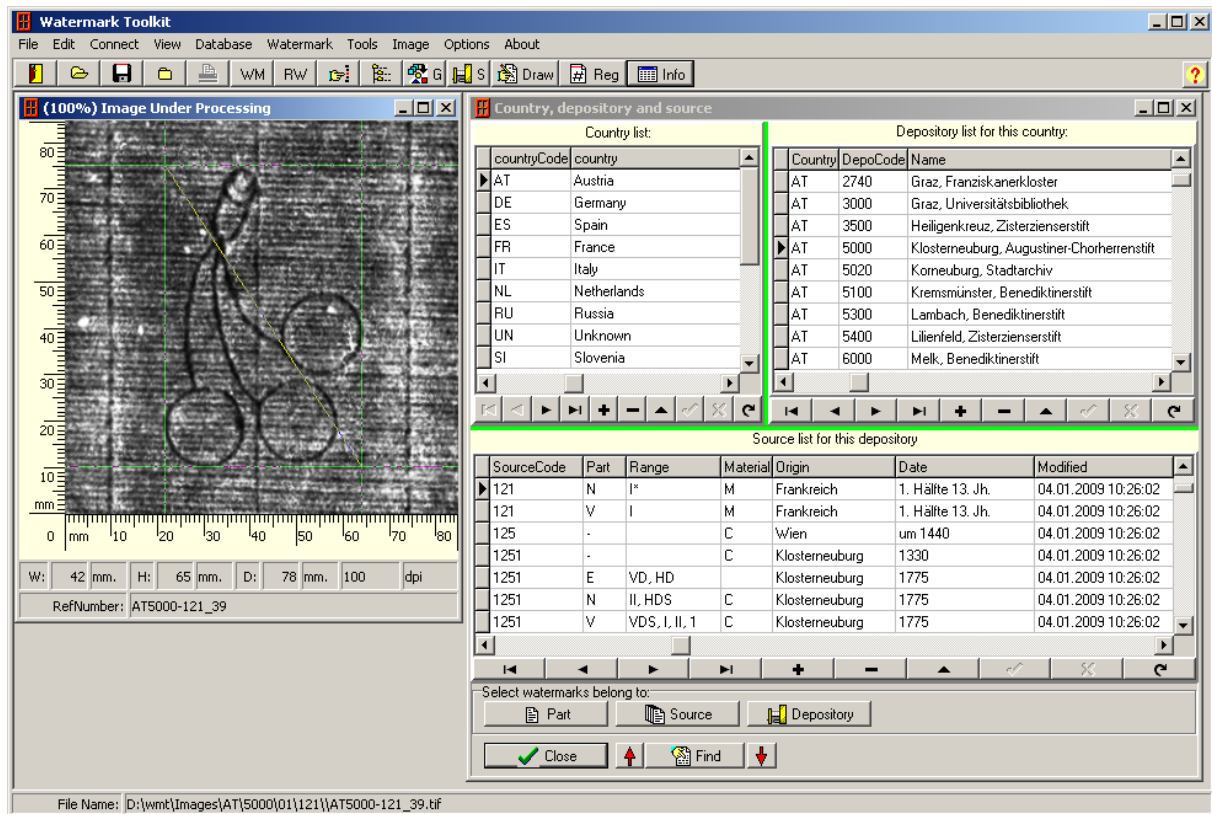


Figure 3: Screen shot of the main WMT interface form with two open children interface forms: “Image under processing” and “Country, depository and source”.

#### 4.1 Watermark Motif Classification

The watermark classification functionality of the WMT is based on the watermark classification scheme that was suggested, developed and elaborated by the Bernstein consortium. The WMT classification functionalities are the foundation stones and backbones of the developed tools. The developed watermark classification scheme is a motif based hierarchical one. It consists of a set of basic motifs. Each basic motif can have up to 9 subordinated motif levels of a hierarchical tree. Any motif tree level, including the basic one, can have up to 999 motifs. This classification structure has the capacity that is sufficient for any reasonable extension of the motif classification scheme for the known watermark collections.

The description of each subordinated motif at any level of the tree, excluding the basic level, is a further detail description of the preceding (parent) motif. The current version of the Bernstein classification scheme consists of 11 basic motifs and 1253 subordinated detailed motifs. The basic motifs of this scheme have from 4 and up to 8 subordinated motif levels.

A screen short of the WMT interface form for support of the Bernstein watermark motif classification structure is presented on the Figure 4.

All motifs of the Bernstein classification scheme are presented by corresponding nodes of a tree view structure that graphically presented on Figure 4. The basic motifs are presented by the corresponding nodes (marked by the green icons) of the left most column. The motifs of the second level are presented by the corresponding nodes (marked by the green icons) of the second column (adjacent to the basic level) and so forth. Each node of this structure has the label that consists of the short code of the node (three numbers), symbol ‘:’ and a last text part of the label. This last text part of the label is used as the short description of the node. The full description of a motif is generated as a string concatenation of the short descriptions of all preceding nodes starting from the basic one. The code part of the label is used internally by the WMT for the multilingual support of the Bernstein watermark motif classification

functionality. The WMT has a big set software tools for the computer aided development and modification of this structure.

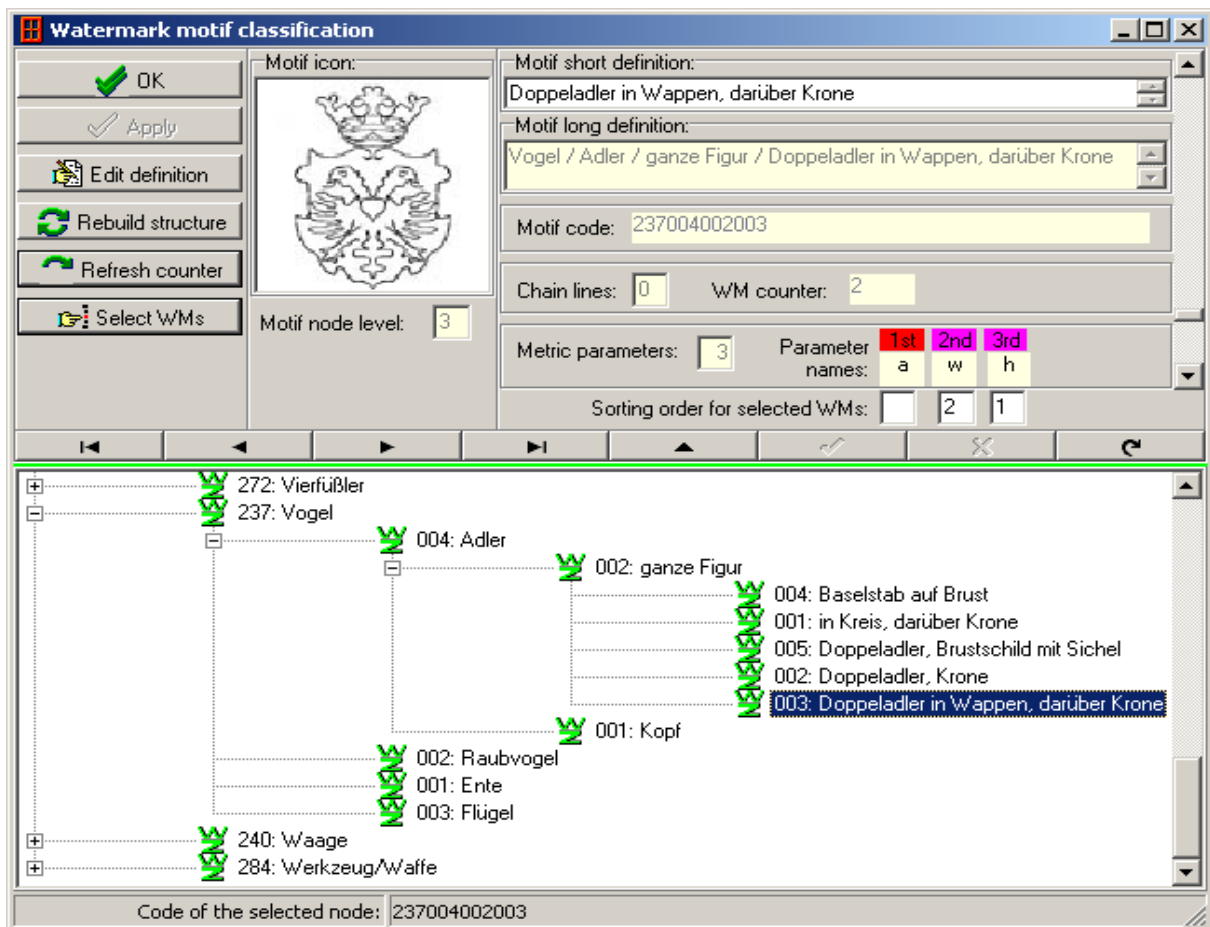


Figure 4: WMT interface form for support of the Bernstein watermark motif classification structure.

#### 4.2 Watermark Identification and Registration

The WMT exploit a user-friendly algorithm for watermark identification and registration in the watermark database. It takes the following data concerning the watermark to be registered and/or identified in the database:

- Two letter country code (see ISO 3166-1 alpha -2) (CC);
- Four number depository code (DC);
- Free length source code (SC);
- Free length folio (page) code (FC).

The reference number of a watermark is generated as a sequence of alpha-numerical characters, the linking character '-' (hyphen) and the linking character '\_' (underscore). The WMT generates watermark reference numbers by using the following symbolic form:

$$(CC)(DC)-(SC)_(FC),$$

where the length of the parameters (SC) and (FC) must be equal at least to one symbol. So, the minimal length of any watermark reference number is equal to 10 symbols. The maximal length of the any watermark reference number must not exceed 32 symbols. An example of the watermark reference number is presented on Figure 3 (see the status bar of the form "Image under processing"). It is "AT5000-121\_39".

The registration procedure of watermarks in the Bernstein compatible database is based on the presented above symbolic form for generation of the watermark reference numbers. The screen shot of the WMT graphical form for watermark registration is presented on Figure 5.



The file name and file location of the registered watermark image is generated by the WMT and stored in the database too. These data are shown at the bottom part of the form.

#### **4.3 Measurement of Metric Parameters**

The metric parameters are an effective means for a preliminary watermark comparison and selection. Some of these parameters are determined as distances between key points of watermarks. The “width” and “height” of the bounding box of the watermark, the “distance” between chain lines surrounding the watermark, the “width” or “height” of specific watermark elements are widely used as metric parameters.

The WMT offers an integrated user-friendly interactive tool for the retrieving of the bounding boxes and the calculation of the required watermark parameters: height, width and distance. The user can retrieve up to six metric parameters and insert these data into the database by simple clicking onto the proper entry control or by pressing a predefined hotkey of the watermark identification interface form. A screen shot of the main WMT interface form presented on Figure 6 contains this form (see the right site of the main interface form). An example of the bounding box is visible on the form “Image under processing” (see the left site of the main interface form). The number of the required metric parameters to be captured is a part of the watermark motif definition and can vary from 3 to 6. A screen shot of the watermark comparison interface form is presented on Figure 7.

#### **4.4 Watermark Comparison and Watermark Relations**

The watermark comparison is the final step of the main processing stream of watermarks in the WMT. The aim of the comparison process is to find similar watermarks in the watermark database. The WMT supports three following kinds of relations between watermarks:

- Equal;
- Variant;
- Repertory type (i.e. is similar to a repertory watermark).

The WMT uses for the comparison routines a special interface form where two compared watermark images are loaded in two semi-transparent layers one over the other. The user is getting the result of comparison by changing the transparency of layers, switching on/off the flickering comparison effect, slightly shifting and/or slightly rotating images one with the respect to the other. The found relations are registered in the database and can be used any time for the watermark studies.

#### **4.5 Digital Image Processing**

Some of the watermark images have a visual quality and/or other visual characteristic that restrict the effective usage of them for watermark studies. The WMT offers a set of the image processing routines for digital processing of watermark images aimed to:

- Image contrast enhancement;
- Noise suppression;
- Image resolution measurement and image scaling;
- Geometrical transformations.

These and other routines can be invoked from the main or pop-up menus at any time to process the image under processing.

#### **4.6 Multilanguage Capability**

The developed software is designed in the manner that provides multilingual support for watermark studies. The current version is deployed with data those are ready to support the watermark classification and identification in six languages (English, French, German, Italian, Russian and Spanish) additional languages can be added as additional language resources.

## Conclusions

The collection of ready-to-use tools and data that gives people the mean to set up their own digital services for paper watermark studies, such as the Bernstein concordant watermark database and the Bernstein compatible application software is developed, created and is available for downloading. The main stream of the watermark processing in the WMT can be summarized as follows:

- Watermark registration in the watermark database by using the interface form presented on Figure 5.
- Watermark motif definition for the registered watermark by selecting the proper node of the motif classification tree view structure presented on the Figure 4.
- Measurement of the watermark metric parameters required for the detailed identification of the watermark by using the interactive tools and forms presented on the Figure 6.
- Watermark comparison aimed to finding the similar (equal, variant or repertory type) watermarks by using the interface form presented on Figure 7. The related watermarks can be used any time for further dating and other watermark studies.

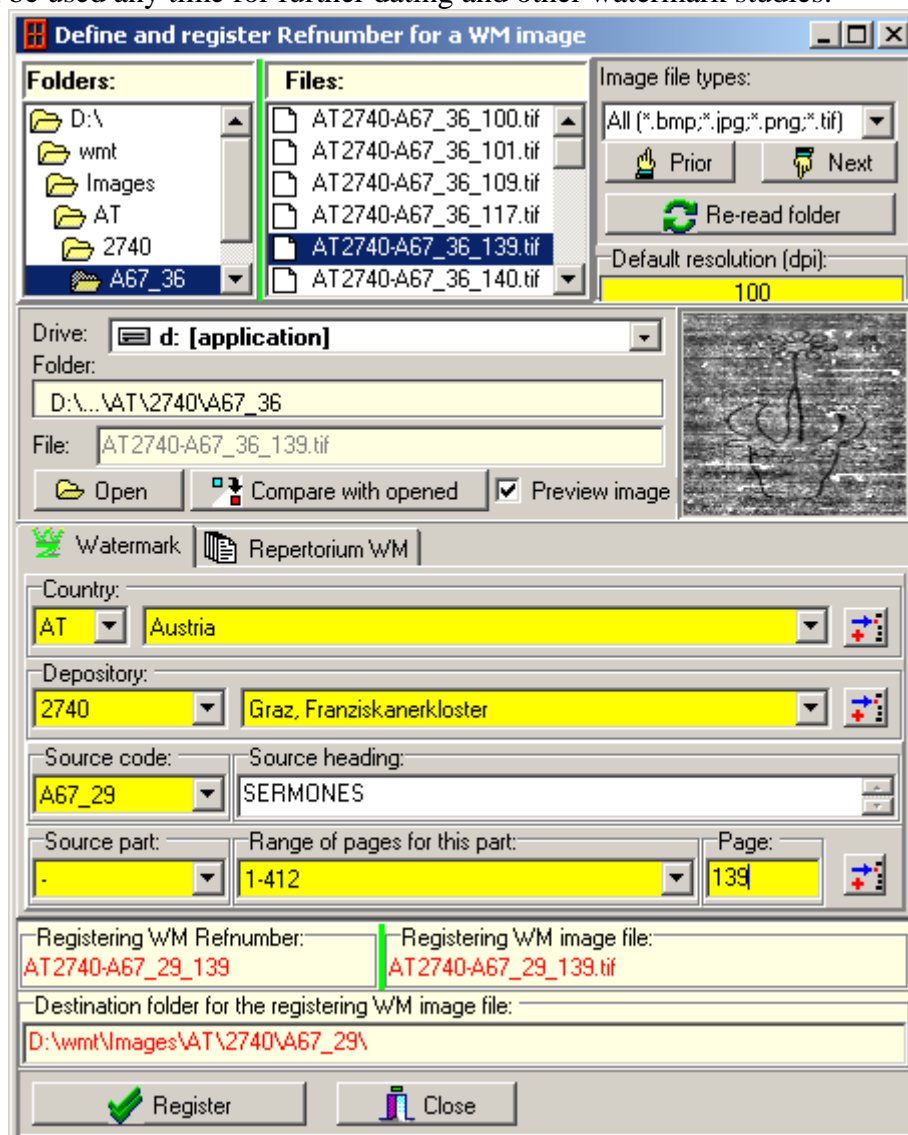


Figure 5: Screen shot of the WMT graphical interface form for watermark registration.

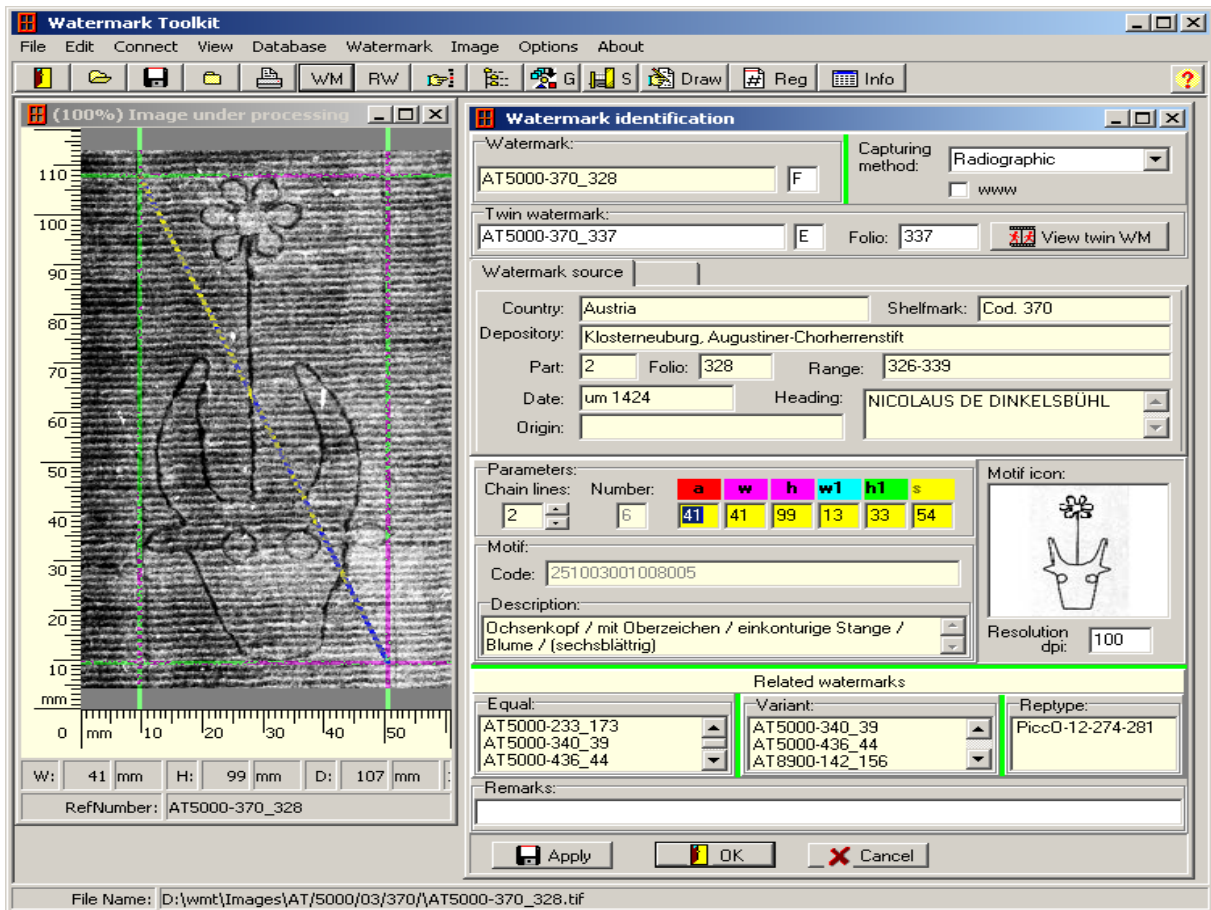


Figure 6: Screen shot of the main interface form captured during the “Measurement of Metric Parameter” process. It contains the form “Image under processing” with the visible bounding watermark box. The “Watermark identification” interface form is arranged at the right side of the main form.

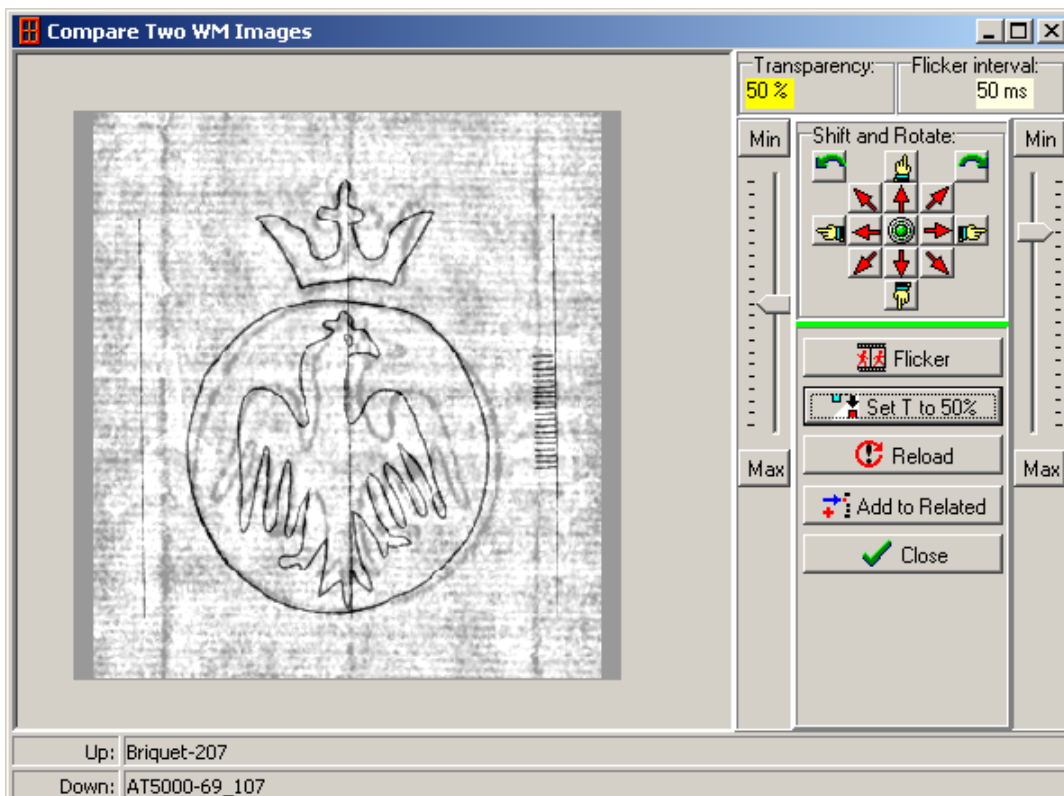


Figure 7: Screen shot of the watermark comparison form.

## Appendix A

### *The Bernstein compatible database table structures and definitions*

#### **Table Country:**

##### **Field Names:**

`IDcountry`  
 `CountryCode`  
 `Country`  
 `Modified`

##### **Data Definition:**

```
CREATE TABLE `country` (
  `IDcountry` smallint(6) unsigned NOT NULL auto_increment,
  `CountryCode` char(2) NOT NULL,
  `Country` varchar(40) NOT NULL,
  `Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,
  PRIMARY KEY (`CountryCode`),
  UNIQUE KEY `By_country` (`Country`),
  UNIQUE KEY `By_IDcountry` (`IDcountry`)
) ENGINE=MyISAM AUTO_INCREMENT=17 DEFAULT CHARSET=utf8;
```

#### **Table Depository:**

##### **Field Names:**

`IDdepository`  
 `CountryCode`  
 `DepoCode`  
 `Name`  
 `Location`  
 `GISdata`  
 `Modified`

##### **Data Definition:**

```
CREATE TABLE `depository` (
  `IDdepository` smallint(6) unsigned NOT NULL auto_increment,
  `CountryCode` char(2) NOT NULL,
  `DepoCode` char(4) NOT NULL,
  `Name` varchar(255) NOT NULL,
  `Location` varchar(50) default NULL,
  `GISdata` varchar(30) default NULL,
  `Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,
  PRIMARY KEY (`IDdepository`),
  UNIQUE KEY `IDdepository` (`IDdepository`),
  UNIQUE KEY `By_Name` (`CountryCode`,`Name`),
  UNIQUE KEY `By_DepoCode` (`CountryCode`,`DepoCode`)
) ENGINE=MyISAM AUTO_INCREMENT=144 DEFAULT CHARSET=utf8;
```

#### **Table Motif:**

##### **Field Names:**

`MotifCode`

```

`MotifIndex`
`IDmotif`
`MotifShort`
`MotifLong`
`WmCounter`
`Chainlines`
`Parnumber`
`Parname4`
`Parname5`
`Parname6`
`Modified`
`Remarks`

```

**Data Definition:**

```

CREATE TABLE `motif` (
  `MotifCode` varchar(30) NOT NULL,
  `MotifIndex` smallint(5) unsigned NOT NULL,
  `IDmotif` smallint(5) unsigned NOT NULL,
  `MotifShort` varchar(75) NOT NULL,
  `MotifLong` varchar(255) default NULL,
  `WmCounter` smallint(6) unsigned default NULL,
  `Chainlines` char(2) default NULL,
  `Parnumber` tinyint(4) unsigned default '3',
  `Parname4` char(2) default NULL,
  `Parname5` char(2) default NULL,
  `Parname6` char(2) default NULL,
  `Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,
  `Remarks` varchar(100) default NULL,
  PRIMARY KEY (`MotifCode`),
  KEY `MotifCode` (`MotifCode`)
) ENGINE=MyISAM DEFAULT CHARSET=utf8;

```

**Table Related:****Field Names:**

```

`IDrelated`
`RefNumber`
`egID`
`isVariant`
`tg1ID`
`tg2ID`
`tg3ID`
`Modified`

```

**Data Definition:**

```

CREATE TABLE `related` (
  `IDrelated` mediumint(9) unsigned NOT NULL auto_increment,
  `RefNumber` varchar(30) NOT NULL,
  `egID` mediumint(9) default NULL,
  `isVariant` tinyint(1) default NULL,

```

```

`tg1ID` mediumint(9) default NULL,
`tg2ID` mediumint(9) unsigned default NULL,
`tg3ID` mediumint(9) default NULL,
`Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,
PRIMARY KEY (`IDrelated`),
UNIQUE KEY `IDrelated` (`IDrelated`),
UNIQUE KEY `RefNumber` (`RefNumber`)
) ENGINE=MyISAM AUTO_INCREMENT=11834 DEFAULT CHARSET=utf8;

```

**Table Source:****Field Names:**

```

`IDsource`
`IDsourcebase`
`IDdepository`
`SourceCode`
`Part`
`Range`
`Material`
`Origin`
`Date`
`Modified`
`Remarks`

```

**Data Definition:**

```

CREATE TABLE `source` (
  `IDsource` mediumint(8) unsigned NOT NULL auto_increment,
  `IDsourcebase` mediumint(8) unsigned NOT NULL,
  `IDdepository` smallint(6) unsigned default NULL,
  `SourceCode` varchar(25) default NULL,
  `Part` varchar(5) NOT NULL,
  `Range` varchar(40) default NULL,
  `Material` char(1) default NULL,
  `Origin` varchar(75) default NULL,
  `Date` varchar(35) default NULL,
  `Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,
  `Remarks` varchar(100) default NULL,
  PRIMARY KEY (`IDsource`),
  UNIQUE KEY `IDsource` (`IDsource`),
  UNIQUE KEY `By_Part` (`IDsourcebase`,`Part`),
  UNIQUE KEY `By_IDdepository` (`IDdepository`,`SourceCode`,`Part`)
) ENGINE=MyISAM AUTO_INCREMENT=2754 DEFAULT CHARSET=utf8;

```

**Table Sourcebase:****Field Names:**

```

`IDsourcebase`
`IDdepository`
`SourceCode`
`Shelfmark`
`Heading`
`MaterialBase`

```

`NumLeaves`  
 `Dimensions`  
 `OriginDate`  
 `Modified`  
 `Remarks`

**Data Definition:**

```
CREATE TABLE `sourcebase` (
  `IDsourcebase` mediumint(8) unsigned NOT NULL auto_increment,
  `IDdepository` smallint(6) unsigned NOT NULL,
  `SourceCode` varchar(25) NOT NULL,
  `Shelfmark` varchar(75) default '0',
  `Heading` mediumtext,
  `MaterialBase` varchar(25) default NULL,
  `NumLeaves` varchar(50) default NULL,
  `Dimensions` varchar(50) default NULL,
  `OriginDate` varchar(250) default NULL,
  `Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,
  `Remarks` varchar(100) default NULL,
  PRIMARY KEY (`IDsourcebase`),
  UNIQUE KEY `IDsourcebase` (`IDsourcebase`),
  UNIQUE KEY `IDdepository` (`IDdepository`,`SourceCode`)
) ENGINE=MyISAM AUTO_INCREMENT=1009 DEFAULT CHARSET=utf8;
```

**Table Wmarks:****Field Names:**

`IDwmarks`  
 `Refnumber`  
 `IDsource`  
 `Folio`  
 `www`  
 `IDmotif`  
 `MotifCode`  
 `Path`  
 `FolioTwinWm`  
 `WmCode`  
 `Chainlines`  
 `ParA`  
 `ParW`  
 `ParH`  
 `Par4`  
 `Par5`  
 `Par6`  
 `IDmethod`  
 `Modified`  
 `Remarks`

**Data Definition:**

```
CREATE TABLE `wmarks` (
```

```

`IDwmarks` mediumint(8) unsigned NOT NULL auto_increment,
`Refnumber` varchar(25) NOT NULL,
`IDsource` mediumint(9) unsigned NOT NULL,
`Folio` varchar(8) default NULL,
`www` tinyint(3) unsigned default '1',
`IDmotif` mediumint(8) unsigned default NULL,
`MotifCode` varchar(30) default NULL,
`Path` varchar(255) default NULL,
`FolioTwinWm` varchar(8) default NULL,
`WmCode` varchar(3) default NULL,
`Chainlines` varchar(2) default NULL,
`ParA` smallint(6) default NULL,
`ParW` smallint(6) default NULL,
`ParH` smallint(6) default NULL,
`Par4` smallint(6) default NULL,
`Par5` smallint(6) default NULL,
`Par6` smallint(6) default NULL,
`IDmethod` tinyint(5) unsigned default '0',
`Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,
`Remarks` varchar(75) default NULL,
PRIMARY KEY (`IDwmarks`),
UNIQUE KEY `IDwmarks` (`IDwmarks`),
UNIQUE KEY `Refnumber` (`Refnumber`)
) ENGINE=MyISAM AUTO_INCREMENT=10812 DEFAULT CHARSET=utf8;

```

**Table Wmrep:****Field Names:**

```

`IDwmrep`
`RefNumber`
`IDrepertory`
`WmNumber`
`WmGroup`
`Date`
`IDmotif`
`MotifCode`
`Chainlines`
`ParA`
`ParW`
`ParH`
`Par4`
`Par5`
`Par6`
`FolioTwinWm`
`Modified`
`Remarks`

```

**Data Definition:**

```

CREATE TABLE `wmrep` (
  `IDwmrep` mediumint(9) unsigned NOT NULL auto_increment,
  `RefNumber` varchar(25) NOT NULL,

```



```
`IDrepertory` smallint(5) unsigned default NULL,  
`WmNumber` varchar(25) default NULL,  
`WmGroup` tinyint(1) NOT NULL default '0',  
`Date` varchar(50) default NULL,  
`IDmotif` mediumint(9) unsigned default NULL,  
`MotifCode` varchar(30) default NULL,  
`Chainlines` char(2) default NULL,  
`ParA` smallint(6) unsigned default NULL,  
`ParW` smallint(6) unsigned default NULL,  
`ParH` smallint(6) unsigned default NULL,  
`Par4` smallint(6) unsigned default NULL,  
`Par5` smallint(6) unsigned default NULL,  
`Par6` smallint(6) unsigned default NULL,  
`FolioTwinWm` varchar(8) default NULL,  
`Remarks` varchar(25) default NULL,  
`Modified` timestamp NOT NULL default CURRENT_TIMESTAMP,  
PRIMARY KEY (`IDwmrep`),  
UNIQUE KEY `By_refNumber` (`RefNumber`),  
UNIQUE KEY `RefNumber` (`RefNumber`)  
) ENGINE=MyISAM AUTO_INCREMENT=300345 DEFAULT CHARSET=utf8;
```